PRAIRIE RESEARCH INSTITUTE
Illinois Natural History Survey
1816 S. Oak Street
Champaign, IL 61820

The Forests and Woodlands Campaign of the Illinois Wildlife Action Plan – Segment 8

Hoover, Jeffrey P.

INHS Technical Report 2018

Prepared for IDNR Division of Wildlife

Issued on 12/01/2018

Release online immediately;

Final Report for W-162-R-8

The Forests and Woodlands Campaign of the Illinois Wildlife Action Plan – Segment 8

(i) Project Information

a) Project Title: The Forests and Woodlands Campaign of the Illinois Wildlife Action Plan

b) Project Number: W-162-R-8

c) Legal Name of Entity doing the Project: The Board of Trustees of the University of Illinois

d) Period of Time covered by this report is 09/01/2017-08/31/2018

e) Due Date of the Final Report is 11/01/2018

f) Principle Investigator: Jeff Hoover, Avian Ecologist, Illinois Natural History Survey, University of Illinois, 1816 S. Oak Street, Champaign, IL 61820, 217-244-2922, j-hoover@illinois.edu

g) IDNR collaborator and contact: Luke Garver, Wild Turkey Project Manager, Illinois Department of Natural Resources, One Natural Resources Way, Springfield, IL 62702-1271, 217-782-4377, Luke.Garver@illinois.gov

Overview and Objectives

The Forests and Woodlands Campaign (Forest Campaign hereafter) is one of the many important campaigns outlined in the Illinois Comprehensive Wildlife Conservation Plan and Strategy (wildlife action plan). The wildlife action plan highlights very well the many current conservation issues involving Illinois' wooded habitats including the alteration or loss of natural disturbance processes, changing composition of forested habitats away from oak-hickory to maple dominance, general decline in forest quality caused by increasing numbers of invasive exotic plant species, and extensive forest fragmentation. While the wildlife action plan provides direction in the form of a general list of priority actions, the Forest Campaign, over the next several years will specifically move the wildlife action plan forward by:

a) Using the best science available to establish and continue using monitoring protocols to measure the effectiveness of forest management activities and determine whether or not wildlife are responding to these activities;

b) Establishing demonstration sites where land managers and the public can observe and learn more about forest management in action and how it benefits wildlife.

In addressing these needs, the Forest Campaign will establish or reinforce forest management partnerships in Illinois, create protocols for monitoring the effects of forest management activities on Illinois' wildlife, and document whether or not forest management activities are successfully promoting populations of focal wildlife species and meeting the goals of the wildlife action plan.

To better understand the response of wildlife populations to forest management activities under the wildlife action plan, Segment 8 of the Forest Campaign was devised to meet the following objectives (1 September 2017 through 31 August 2018):

1) Continue the implementation of monitoring protocols that measure the response of forest wildlife to various forest management tools including, but not limited to, thinning, fire, timber harvest, and the removal of invasive exotic plant species;

2) Use a “before-after-treatment-control” monitoring framework (with replication) at 6 or more sites across Illinois (more than 450 established survey points each visited multiple times per year) to document the immediate and longer-term effects of forest management on populations of forest and woodland-dwelling birds and other wildlife;

3) Specifically, to use breeding bird point counts (~450 points distributed among 5 study sites each visited twice when possible during May-July), “camera traps” (~50 point subset of the 450 survey points each surveyed with a 7-day camera deployment), and nocturnal nightjar surveys (at least 10 survey points at each of 3 study sites, each point visited 2 times during late April and early June), all in conjunction with vegetation surveys (~225 point subset of the 450 survey points sampled during July-August and representing the various treatments and controls) to document how management activities affect forest structure and composition and in turn influence particular wildlife species.

4) One popular article about this project will be provided to the Illinois Department of Natural Resources by the grant end date. This article will be approximately 500 words in length with at least 2 pictures provided.

Methods

To meet the first objective of continuing to monitor songbirds at a number of sites throughout Illinois, we revisited all those points at five of the six locations surveyed during Segment 7 including the Shawnee National Forest (Oakwood Bottoms), Trail of Tears State Forest, Lake Shelbyville - U.S. Army Corps of Engineers, and Stephen A. Forbes and Siloam Springs State Parks. In subsequent grant segments, we will adaptively add additional survey points to Ramsey Lake State Recreation Area (which has several years of ongoing forest management), and will re-engage with breeding bird surveys at Hidden Springs State Forest as additional forest management at that site starts up again.

During the field season associated with Segment 8, various types of surveys were completed at previously-established survey points that have also been visited in prior years. Because we do not have control over where and when the various types of forest management occur, each year a given survey point has a new management history associated with it. One thing that remains constant is that also survey “control” (not managed) points to use as the basis for comparison with the different management histories that our survey points encompass.

Bird Surveys: Survey points were visited and a standard point-count technique used to determine breeding forest songbird species diversity and relative abundance for different forest treatment categories (including non-managed control areas) at each study site. Each survey point was visited two times (if possible) during the breeding survey period (May 15 to July 15).

Nightjar Surveys: At Stephen A. Forbes State Park, and Trail of Tears and Hidden Springs State Forests, we conducted nocturnal surveys to assess nightjar (Whip-poor-wills and Chuck-will’s-widows) populations. These surveys were completed during May and June (visiting each nocturnal survey point at least twice a month) and followed basic nightjar survey

protocols including broadcasting playbacks of nightjar calls to elicit responses from any birds that may be present. We visited 10 established points at each of the three sites (located in both managed and non-managed forests) after sunset along the trail and road systems and listened for singing nightjars. Counts at each point last 10 minutes and after a set number of minutes of just listening we broadcast nightjar calls, and then listened for the remaining minutes.

Camera Traps: To evaluate the activity of other animals (including some that are known nest predators) in response to forest management, we conducted trail-camera surveys during 2018. These included late-spring/early-summer surveys within different forest management categories at Trail of Tears, Forbes and Lake Shelbyville areas. Cameras were deployed for one week to four locations representing three forest management categories at each of the three areas (4x3x3=36 deployments). Cameras were baited with fatty-acid tablets to attract mesocarnivores. Images were uploaded following each camera deployment. We used the number of detections of various animals (controlling for effort) as an index of “activity” or “use” of various forest management regimes at each study area.

Vegetation Sampling: At the various survey points in each area, vegetation data (e.g. visual obstruction measures in the understory, ground cover amount and type, shrub density and diversity, canopy cover, tree-species composition) was collected using a modified Breeding Biology Research and Monitoring Database protocol. The vegetation data will be important to explaining variation in use of different areas by songbirds and will complement any additional data being collected by site managers to document the response of the forest vegetation to the management activities.

(ii) Actual Accomplishments vs. Project Objectives

a) **Objective 1** – Continue monitoring the response of forest wildlife to various forest management tools that include, but are not limited to, thinning, fire, re-forestation, and the removal of invasive exotic plant species.

This segment represents another year of an ongoing project. Given the long-term nature of forest management, and wildlife and vegetation responses to that management, continued consistent and methodical monitoring of responses is required to tease apart immediate (e.g. happening immediately following forest management), short-term (e.g. happening 2-5 years after forest management commences), and longer-term (e.g. >5 years to decades after forest management commences) effects of forest management. In this segment we continued to successfully monitor the responses of forest wildlife to various forest management histories.

b) **Objective 2** – Use a "before-after-treatment-control" monitoring framework (with replication) at 6 or more sites across Illinois (more than 450 established survey points each visited multiple times per year) to document the immediate and longer-term effects of forest management on populations of forest and woodland-dwelling birds and other wildlife;

We met this objective by continuing to monitor forest and woodland-dwelling songbirds at survey points located among 5 study sites representing locations that have various management histories (see Table 1 for some examples), and control locations that are not slated to or have not yet experienced management. Doing this at several survey points for each management category within sites, and at multiple sites yields two levels of replication. This year we did not visit Hidden Springs as there was not active management occurring there this past season and because we had added additional points to Siloam Springs and Lake

Shelbyville to better assess new/ongoing forest management at those locations. We intend to return to Hidden Springs in the next segment as more forest management is slated to occur there in the next year.

c) **Objective 3** – Specifically, to use breeding bird point counts (~450 points distributed among 5 study sites each visited twice when possible during May-July), “camera traps” (~50 point subset of the 450 survey points each surveyed with a 7-day camera deployment), and nocturnal nightjar surveys (at least 10 survey points at each of 3 study sites, each point visited 2 times during late April and early June), all in conjunction with vegetation surveys (~225 point subset of the 450 survey points sampled during July-August and representing the various treatments and controls) to document how management activities affect forest structure and composition and in turn influence particular wildlife species.

This objective was met in most instances (including collecting data at 5 locations). Fewer than expected vegetation points were surveyed in Oakwood Bottoms because of late-summer flooding that affected much of the site and made several points inaccessible. Winter point counts may be included once every 3 years in order to have some information on bird use of managed forests during the winter, particularly woodpeckers, but were not conducted this segment.

d) **Objective 4** – One popular article about this project will be provided to the Illinois Department of Natural Resources by the grant end date. This article will be approximately 500 words in length with at least 2 pictures provided.

This last objective will be met immediately following completion of this report. I will be submitting a 500 word article and two images to IDNR that highlights some of the results of this past years work.

Results and Discussion

A summary of the number of bird survey locations at each site and the forest management treatments associated with them is provided in Table 1. Vegetation surveys were completed at half of these points (specifically at Trail of Tears, Oakwood Bottoms, and Lake Shelbyville). Included below are general site descriptions and summaries of what was accomplished during Segment 8 of the Forest and Woodlands Campaign. Discussion of the effects of forest management on relative abundances of breeding birds are limited to those species that had relative abundances of at least 0.10 individuals per 100m-radius point.

Oakwood Bottoms Research Summary

Oakwood Bottoms Greentree Reservoir, located in Jackson County northeast of Grand Tower, Illinois, has been managed since 1964. Pin oaks and scattered cherrybark oaks are flooded during the fall and drained before the onset of the growing season to simulate flooding conditions that would naturally be expected in the Mississippi River bottomlands. Because the Big Muddy River levee prevents natural flooding of this site, flooding is accomplished by pumping water. As a result of tight soils and little drainage relief, the area is primarily a wet forest.

Beginning in 2007 thinning was employed to open the forest canopy on almost 1400 acres of the forest, nearly 17,000 container stock oaks were planted, and prescribed fires were initiated when and where conditions allowed. The thinning is being done within smaller sub-

plots (ranging in size from 1 to 7 acre “openings”) within various units of the site and includes the thinning of non-oaks in the understory and overstory within sub-plots. Smaller trees and saplings are cut down while larger non-oak trees are girdled or more-recently harvested. In combination, this approach provides greater light and less competition for the oak seedlings and saplings present in the understory while leaving the larger non-oaks to serve as snags and cavity trees for use by various wildlife.

Breeding Bird Point Count Survey Data. A total of 58 species were documented at bird survey points in Oakwood Bottoms and all 58 were within 100m of the survey points and eligible for inclusion in estimates of species diversity and relative abundance. For the purposes of a general summary, bird surveys associated with the different forest management treatment types were grouped together into six categories (Table 1). The mean species diversity per survey point did not differ among categories (Figure 1).

The bird survey results from the 2018 breeding season at Oakwood Bottoms are summarized in Table 2. The various types of forest management are having a similar amount of positive and negative effects on the relative abundance of forest birds. Of the 31 species common enough to assess a response (positive, negative, mixed, or neutral; highlighted in Table 2) to management activities, 13 species (42%) of forest birds showed a **positive response** at Oakwood Bottoms (**abundance higher in one or more treatment categories compared to no-management category**), including some species that are on the SGNC list for Illinois such as Yellow-breasted Chat and Red-headed Woodpecker (examples given in Figure 2). Fourteen species had a **negative response** to the treatments (**abundance higher in the no-management category than one or both of the other categories**), including Acadian Flycatcher and Yellow-billed Cuckoo which are SGNC species (examples given in Figure 3). Four species had a **mixed response** (**more abundant in one management**

category and less abundant in the other compared to the no-management category; see Figure 4) and none had a **neutral response** (**similar abundance across all categories**). Species that are known to associate strongly with more-open forest canopies (e.g. American Redstart, Prothonotary Warbler, and Red-headed Woodpecker), more-complex (heterogeneous) forest structure (e.g. White-eyed Vireo), or more-dense shrub layer and ground cover (e.g. Common Yellowthroat, Yellow-breasted Chat, Eastern Towhee, and Yellow Warbler) tended to be the ones more abundant in the forest units where thinning has occurred (Figure 2). Those species showing a negative response to the various management categories (primarily a response to thinning) included species that tend to like closed canopy forests with a well-developed sub-canopy (e.g. Acadian Flycatcher, Red-eyed Vireo, and Summer Tanager; Figure 3). These negative responses are likely temporary and should reverse as tree species composition goals are achieved and the forest sub-canopy and canopy slowly fill back in. Of the species showing a mixed response to forest management, the Carolina Wren and Great-crested Flycatcher showed a particularly strong positive response to recent TSI plus a 2018 midstory removal, whereas the Kentucky Warbler responded well to TSI alone (Figure 4). Table 7 summarizes by management category the various metrics of forest vegetation which are the likely drivers of breeding bird relative abundances. In general, the mosaic of forest habitat (managed and non-managed) provides for a robust breeding bird community at Oakwood Bottoms. The forest management at Oakwood Bottoms is having a neutral effect on the diversity of breeding bird species at the site, and predictable effects (based on natural histories and habitat needs) on their relative abundances. If the forest management at Oakwood Bottoms is meeting forest composition/structure goals, it is doing so while have a net neutral effect on the breeding bird community. As the effects of forest management on the structure of the forest play out over the next several years, we will be able to assess the

longer-term effects of management on the breeding bird community, forest structure and tree species composition.

Cowbird Abundance. A concern for breeding forest songbirds when thinning opens up the forest canopy or prescribed fire reduces/removes ground cover, is the potential for increased brood parasitism of songbird nests by Brown-headed Cowbirds. Female cowbirds may cue in on or use more heavily areas of the forest where the canopy has been opened up or prescribed fire used. The more-open canopy may make it easier for female cowbirds to view the nest building and mating activities of potential hosts while the cowbirds are searching for nests to parasitize. Female cowbirds may also be able to successfully forage for insects and exposed seeds on the forest floor in recently burned areas, reducing their need to leave the forest to forage in nearby non-forest areas (e.g. pasture, row-crop, or mowed areas). This could lead to higher rates of cowbird parasitism in forests that are thinned and/or recently burned than those not. In 2018, overall cowbird detections were somewhat lower compared to the previous 3 years (**0.38** vs. 0.46, 0.46, and 0.47, respectively). Cowbird detections were **not** higher in any particular management category, and tended to be lower in most (Table 2). Therefore, it is likely that the current forest management practices at Oakwood Bottoms will **not** increase cowbird parasitism of songbird nests. The overall abundance of cowbirds at the site suggests that rates of brood parasitism are likely moderate to low throughout the site.

Lake Shelbyville Research Summary

At the Lake Shelbyville Wildlife Management Area located in east-central Illinois, oak, hickory and hard maple flourish in the uplands. Improvements to the forest which consist of thinning the trees to enhance mast production and understory growth (e.g. 150-400 acres per

year since 2008), nesting cover establishment, prescribed burning, and invasive species eradication (such as bush honeysuckle and autumn olive), are all being implemented on Lake Shelbyville to enhance the overall habitat. Between the 2017 and 2018 breeding seasons, aerial chemical spraying with and without prescribed fire were added as a new approach to reduce bush honeysuckle in the understory of the forest. This occurred in some areas where our survey points have been established for years, and in other areas where we adaptively added new points to assess the effects of this new management approach on breeding birds. The active management on the site, including thinning, prescribed fire, and invasive-exotic plant species eradication, lends itself to obtaining before-after-treatment-control data to better understand the effects of this management on various species of forest birds.

Breeding Bird Point Count Survey Data. A total of 75 species were documented at bird survey points at Lake Shelbyville and all 75 occurred at least once within 100m of survey points making them eligible for inclusion in estimates of species diversity and relative abundance. For the purposes of a general summary, bird surveys associated with the different forest management treatment types were grouped together into seven categories (Table 1). The mean species diversity per survey point differed significantly among categories and was highest in the SPRAY ’18 Rx Fire ’17 TSI >5ya treatment category, intermediate in 3 other treatment and the No Treatment categories, and lowest in the just sprayed and burned and no recent management categories (Figure 5). It is possible that the combination of spraying in 2018 and prescribed fire in 2017 created the most structurally complex forest habitat in this present year, thereby enhancing average species diversity in those areas.

The bird survey results from the 2018 breeding season at Lake Shelbyville are summarized in Table 3. The various types of forest management are having relatively similar amounts of positive, negative, and mixed effects on the relative abundance of forest birds. Of

the 33 species common enough to assess a response (positive, negative, mixed, or neutral; highlighted in Table 3) to management activities, nine species (27%) of forest birds showed a **positive response** to management activities including Northern Flicker (an SGNC), American Robin, Downy Woodpecker, and Great-crested Flycatcher (examples given in Figure 6). Thirteen species (39%) of forest birds had a **negative response** to one or more of the treatments including SGNC such as Yellow-billed Cuckoo, Acadian Flycatcher, and Kentucky Warbler (examples given in Figure 7). Ten (30%) species had a **mixed response** including Wood Thrush (SGNC), Eastern Wood Peewee, and Red-bellied Woodpecker (examples given in Figure 8). Chickadees were the only species that had a **neutral response**. Table 8 summarizes by management category the various metrics of forest vegetation which are the likely drivers of breeding bird relative abundances. In general, the differences in total trees, size A trees, shrub density and ground cover across the management categories are having predictable effects on relative abundances of the breeding birds. Similar to Oakwood Bottoms, the mosaic of forest habitat (managed and non-managed) spread out across the conservation area provides for a diverse breeding bird community at Lake Shelbyville. Recent prescribed fire and/or the spraying chemical defoliant were responsible for some of the negative effects observed, but these are likely relatively short-term in nature or represent a trade-off whereby some species are benefitted (e.g. several species showing mixed responses) while others are not. Many of the species that are currently listed as having a negative response to forest management may have only responded negatively to some types of management while responding neutrally to the others (e.g. Yellow-billed Cuckoo – YBCU; Kentucky Warbler – KEWA; Figure 7). The Wood Thrush is another interesting case in that is tends to occur in highest abundances where the forest is not managed (lots of shrubs and small trees in the understory/midstory of the forest) or in places where there is a lot of bush honeysuckle. Wood

Thrush did not immediately respond negatively to the recent spraying and prescribed fire (WOTH; Figure 8), but they may respond negatively next year if the longer-term effects of that management result in bush honeysuckle being largely eradicated from the understory. These examples highlight how dynamic these responses can be and the importance of collecting several years of data to understand the immediate, short-term and long-term effects of forest management on bird populations. Often there can be an initial (in the year or two after management) negative response of birds to particular forest management practices that become neutral or even positive as years accrue post-management. With additional years of data, we will tease apart the more subtle relationships between management practices and their effects on forest structure and composition and the short- and long-term abundance of various species of forest birds at this location, particularly the effects of fire and their interaction with thinning and/or aerial spraying.

Cowbird Abundance. Brown-headed Cowbirds occurred throughout the site and did not respond to the various forest management treatments with the exception of being less abundant the in the recently sprays and burned areas (BHCO; Figure 8), suggesting that the various types of management are **not** affecting the rates of cowbird parasitism across the site. The overall rate of detection in 2018 was higher than the previous three years (**0.51** vs. 0.33, 0.34 and 0.44, respectively) and is moderate in comparison to the other sites. Cowbird abundances at these levels would suggest that rates of cowbird parasitism are likely moderate across the entire conservation area. We will see next year if this relatively higher abundance is simply annual variation or if cowbirds may be trending upwards for some reason.

The Trail of Tears State Forest is implementing a forest management plan that involves the use of thinning, prescribed fire, and limited harvest within a demonstration area consisting of 3 units. With this in mind, breeding birds were again surveyed in each of the units to get abundance and diversity data associated with the management taking place. In summer 2018 we again surveyed 24 points in 3 additional units where prescribed fire has been used during recent years.

Breeding Bird Point Count Survey Data. A total of 50 species were documented at bird survey points at Trail of Tears and 48 were within 100m of the survey points at least once and eligible for inclusion in estimates of species diversity and relative abundance. For the purposes of a general summary, bird surveys associated with the different forest management treatment types were grouped together into four categories (Table 1). The mean species diversity per survey point was higher in the category representing recent fire and recent harvest compared to the other categories (Figure 9). This result likely stems from there being, on average, more species responding favorably than non-favorably to the recent burn and harvest management and the forest structure that results from it.

The bird survey results from the 2018 breeding season at Trail of Tears are summarized in Table 4. The various types of forest management are having mostly positive, neutral, or mixed effects, along with some negative effects on the relative abundance of forest birds. Of the 31 species common enough to assess a response (positive, negative, mixed, or neutral; highlighted in Table 4) to management activities, 13 species (42%) of forest birds showed a **positive response** to management activities including Acadian Flycatcher and Kentucky Warbler (SGNCs), along with Eastern Wood Peewee, Red-bellied Woodpecker, Summer Tanager and White-eyed Vireo (examples given in Figure 10). Eight species (26%) of forest birds had a **negative response** to one or more of the treatments including SGNC such as

Worm-eating Warbler, Yellow-billed Cuckoo, and Ovenbird (examples given in Figure 11). Two (6%) species had a **mixed response** including Red-eyed Vireo and Brown-headed Cowbird (Figure 12). Eight (26%) species had a **neutral response** including Wood Thrush (SGNC), Tufted Titmouse, Northern Parula and Great-crested Flycatcher (species with overall abundances > 0.10 but not shaded in Table 4). Table 9 summarizes by management category the various metrics of forest vegetation which are the likely drivers of breeding bird relative abundances. In general, the differences in total trees, shrub density, ground cover, and canopy cover across the management categories are having predictable effects on relative abundances of the breeding birds. Species that nest at ground level (e.g. Ovenbird and Worm-eating Warbler) showed a typical negative response to recent prescribed fire, which often reverses itself in 1-2 more years post-fire. Because all of the points in treated areas experienced prescribed fire just prior to the 2018 breeding season, we should be able to document whether these negative effects reverse themselves if these areas are not burned again just prior to the 2019 breeding season. The 2017 tree harvest, separate from effects of prescribed fire, had a positive effect on abundances of Mourning Dove, Kentucky Warbler, White-eyed Vireo, Carolina Wren, and Indigo Bunting, while having a negative effect on Carolina Chickadee and Red-eyed Vireo. The harvest benefited a number of species that like small amounts of disturbance (e.g. tree-fall gaps) and structural complexity in the understory, whereas the loss of a relatively small amount of the tree canopy negatively affected only a few of the many species that nest and forage primarily in the canopy. Collectively, these results support the conclusion that the use of prescribed fire and limited tree harvest as forest management tools at Trail of Tears is generally having a neutral or positive effect on breeding forest birds. Therefore, if it benefits the forest while having relatively few long-term adverse effects on breeding birds, then they are valuable management tools. We will now be able to

document how these species-abundance/forest management relationships change with each additional year post-fire and post-timber harvest, and as more timber-stand-improvement occurs at the site.

This emerging forest management at Trail of Tears involves several additional management units throughout the forest where prescribed fire and/or thinning and some timber harvest are to occur, providing opportunities to add several more survey points in the forest as management occurs in the coming years. As part of the development of the forest management planning process, I have provided the planning group a draft summary of predicted bird responses to the various types of management to be used to promote various forest types (e.g. oak woodland, dry-mesic oak forest, mixed hardwood forest) and oak regeneration. Follow-up research will test these predictions as forest management continues to be implemented.

Cowbird Abundance. Cowbirds occur throughout the Trail of Tears Forest and their overall numbers in 2018 were relatively similar to values from the previous four years (**0.56** vs. 0.62, 0.48, 0.49, and 0.50, respectively) and were somewhat higher in the one management category representing the most intensively burned units (i.e. burned three of the last four years) compared to the other treatment categories. It is possible that the frequent prescribed fire temporarily creates an opportunity for cowbirds to forage on the more open and exposed ground in the forest, reducing their need to leave the forest to forage in nearby openland (e.g. mowed areas, agriculture, pastures, etc.). These overall values of cowbird abundance would likely result in a moderate amount of cowbird parasitism for potential host songbirds breeding at Trail of Tears, with the potential of somewhat higher rates of parasitism in parts of the forest where the frequency of prescribed fire is greatest.

Stephen A. Forbes State Recreation Area Research Summary

Stephen A. Forbes State Recreation Area (Forbes) consists of approximately 3,000 acres of oak and hickory forest surrounding a large impounded lake in south-central Illinois, of which about a third is being actively managed in several units of various sizes. Management at Forbes is focused on maintaining open woodlands with intact canopy through the use of prescribed fire and occasional selective (undesirable and mesic species) sapling removal to promote the desired structure (e.g. density) and species composition of vegetation in the understory of the forest. The management to promote a particular structure and composition of understory vegetation in the forests at Forbes has good potential to shape the breeding bird community at the site. The staff associated with Forbes continues to actively manage several units at the site and maintains a detailed management history for the site over at least the last decade. Timber stand improvement (i.e. thinning via funding from the National Wild Turkey Federation) is now being implemented on parts of the site, where up until recently prescribed fire had been the predominant management tool.

Breeding Bird Point Count Survey Data. A total of 63 species were documented at bird survey points at Forbes and 60 were within 100m of the survey points at least once and eligible for inclusion in estimates of species diversity and relative abundance. For the purposes of a general summary, bird surveys associated with the different forest management treatment types were grouped together into six categories (Table 1). The mean species diversity per survey point was higher in the category representing frequent fires through 2017 and TSI in 2016 compared to the other categories (Figure 13). This result likely stems from there being, on average, more species responding favorably than non-favorably to the TSI and frequent

fires (but no fire in the year preceding the 2018 surveys) and the forest structure that results from that combination of treatments.

The bird survey results from the 2018 breeding season at Forbes are summarized in Table 5. The various types of forest management are having mostly positive or mixed effects on the relative abundance of forest birds. Of the 24 species common enough to assess a response (positive, negative, mixed, or neutral; highlighted in Table 5) to management activities, 11 species (46%) of forest birds showed a **positive response** to management activities including Yellow-billed Cuckoo and Ovenbird (SGNCs), along with Eastern Wood Peewee, Red-bellied Woodpecker, Great-crested Flycatcher and Summer Tanager (examples given in Figure 14). One species (4%), Brown-headed Cowbird, had a **negative response** to most of the treatments (Figure 15). Eleven (46%) species had a **mixed response** including Acadian Flycatcher and Kentucky Warbler (SGNCs), as well as Indigo Bunting and Red-eyed Vireo (examples given in Figure 16). One species, Downy Woodpecker, had a **neutral response** (species with overall abundances > 0.10 but not shaded in Table 5). The TSI had a favorable effect on many species (white- and/or blue-shaded bars taller than others in Figures 14 and 16). Frequent fire, particularly if it was followed by a year of no fire, also favored many species to have higher relative abundances. Some species with mixed responses to forest management responded negatively to a prescribed fire when it occurred just prior to the breeding season. These included species nesting either just above the ground (Kentucky Warbler) or within a couple meters of ground level (Northern Cardinal), or those that might forage primarily in the understory (e.g. Ruby-throated Hummingbird). It is likely that the habitat would again become suitable for nesting for these species at some point within a year, or two at most, after a prescribed fire. If frequent prescribed fire helps the managers to achieve the forest structure and composition they desire, the mixed effects that the prescribed fire has on

birds may be worth it. It may also be possible to reduce the frequency of fires over time which could also prove to have a net benefit for bird species (e.g. some prescribed fire but not too much). The addition of TSI (thinning) to some management units at Forbes seems to have mostly positive effects on the majority of species showing a response to forest management at the site.

Cowbird Abundance. Brown-headed Cowbird overall abundance at Forbes in 2018 was high and comparable to last year but considerably higher than three and four years ago (**0.75** vs. 0.80, 0.25, and 0.24, respectively) and was higher than the other sites. At Forbes, cowbird abundance was lower in four of the five active management categories, and was no higher in the fifth active management category than the no management category. We could reasonably expect parasitism rates to be relatively high at Forbes compared to other sites (with the exception of Siloam Springs) based on the relative abundances of cowbirds among the five study sites, with rates within Forbes possibly being lower in those areas being managed with frequent fire.

Siloam Springs State Park Research Summary

Siloam Springs State Park and the associated Buckhorn Unit stand out as one of the most heavily forested areas within the relatively non-forested west-central part of Illinois. The site has over 3,000 acres of land, with much of it consisting of ridge/gully and rolling topography that is primarily wooded. Challenges in implementing timber management, minimal use of prescribed fire, and the influx of invasive-exotic plant species have all contributed to a reduction in the amount of oak-hickory and open woodland habitat present on the site. One section of the state park has been thinned and had prescribed fire applied every 3-5 years for

the past 20 years. There is a lot of potential at Siloam Springs State Park to manage the site more extensively for upland oak-hickory forest, and open woodland and savanna habitat. More recently (beginning in 2015), with assistance from the National Wild Turkey Federation, there are management units where prescribed fire has been applied and units newly thinned with prescribed fire also applied. As the management at this site continues to be completed, we will be able to track wildlife responses.

Breeding Bird Point Count Survey Data. A total of 49 species were documented at bird survey points at Siloam Springs and 43 were within 100m of the survey points at least once and eligible for inclusion in estimates of species diversity and relative abundance. For the purposes of a general summary, bird surveys associated with the different forest management treatment types were grouped together into five categories (Table 1). The mean species diversity per survey point was not statistically different among categories but tended to be higher in the category representing “no treatment” compared to the other categories (Figure 17). This result likely stems from the relatively widespread use of prescribed fire in the management units within the forest during the past 2-3 years.

The bird survey results from the 2018 breeding season at Siloam Springs are summarized in Table 6. The various types of forest management are having some positive, some mixed, and a fair amount of negative effects on the relative abundance of forest birds. Of the 27 species common enough to assess a response (positive, negative, mixed, or neutral; highlighted in Table 6) to management activities, 7 species (26%) of forest birds showed a **positive response** to management activities including Kentucky Warbler and Yellow-breasted Chat (SGNCs), along with Indigo Bunting, Northern Cardinal, Rose-breasted Grosbeak, Eastern Towhee and Northern Parula (examples given in Figure 18). Fourteen species (44%)

had a **negative response** to one or more of the treatments including SGNCs such as Acadian Flycatcher, Ovenbird and Wood Thrush, as well as other species including Brown-headed Cowbird, Red-eyed Vireo, Blue Jay, both Tanagers, and Red-bellied Woodpecker (examples given in Figure 19). Seven (26%) species had a **mixed response** including Eastern Wood Peewee and Red-headed Woodpecker (SGNCs), as well as American Robin, Downy Woodpecker and Great-crested Flycatcher (examples given in Figure 20). One species, Tufted Titmouse, had a **neutral response** (species with overall abundances > 0.10 but not shaded in Table 6). Recent TSI, and to some extent recent prescribed fire, had a favorable effect on many species that tend to prefer complex forest structure in the understory (e.g. mimics tree-fall gaps and a mosaic of areas of more- and less-dense shrub cover) including Indigo Bunting, Eastern Towhee, Kentucky Warbler and Yellow-breasted Chat (purple- and/or white-filled bars taller than blue in Figure 18). Prescribed fire followed by a year of no fire, also favored some species including Northern Cardinal and Great Crested Flycatcher. Some species with negative or mixed responses to forest management responded negatively to a prescribed fire when it occurred just prior to the breeding season (gray- and/or white-filled bars shorter than others including Red-headed Woodpecker and Great Crested Flycatcher. On the other hand, some species responded well to the “recent prescribed fire only” (i.e. Rx Fire ’18) treatment including American Robin and Carolina Wren. If frequent prescribed fire helps the managers to achieve the forest structure and composition they desire, the mixed effects that the prescribed fire has on birds may be worth it. It may also be possible to reduce the frequency of fires over time which could also prove to have a net benefit for bird species (e.g. some prescribed fire but not too much). The addition of recent TSI (thinning) to some management units at Siloam Springs seems to have a variety of effects on the species breeding in the forest. The dynamic and lagged nature of vegetation responses to management makes it important to monitor

these points for a number of years to fully tease apart the longer term effects of the prescribed fire and thinning.

Cowbird Abundance. Brown-headed Cowbirds were overall more common at Siloam Springs in 2018, 2017 and 2016 (**0.90**, 1.38 and 1.00, respectively) than all other sites in each respective year. In 2018, their abundance dropped a little, possibly just natural annual variation or possibly in response to the large amount of management being done at Siloam Springs. Cowbird abundance at Siloam Springs was much higher at the no treatment points compared to where management has occurred, which may be a small consolation in that it suggests that the forest management is not making any cowbird issues worse. In general rates of cowbird parasitism of songbird nests should be considerably higher at Siloam Springs than the other sites.

Hidden Springs State Forest Research Summary

Hidden Springs State Forest covers over 1,100 acres 10 miles southeast of Shelbyville and consists of three separate tracts of gently rolling land. The terrain is broken occasionally by rugged steep hillsides and the lowlands bordering Richland Creek, which flows through the forest from the northeast to the southwest. Hidden Springs has been managed as a state forest since 1960 and has native trees including white, red, bur, post, pin, shingle and chinquapin oaks, sugar and silver maples, plus hickory, ash, sycamore, black walnut and cottonwood. Introduced species include red cedar, tulip poplar, black locust and red, white and Scotch pines. Various forest management techniques are used at Hidden Springs, and a forest improvement demonstration area located in the southwest section of the forest shows the types of trees that would be removed in properly managed woodlands. For the Forests and

Woodlands Campaign we are monitoring the response of breeding birds to two types of forest management (exotic plant species and maple control with and without the application of prescribed fire) for comparison with non-managed forests at the site. Between the 2017 and 2018 breeding seasons, there had been no management conducted in the forests there that would add new information beyond what had been obtained the previous year. There is a plan to conduct a harvest and some new prescribed fire in the next year, and we will adaptively survey the points at the site when appropriate to document the effects of that emerging new management at Hidden Springs State Forest.

Using Breeding Forest Birds to Measure Responses to Management

Breeding forest songbirds in Illinois include more than 100 different species that fall into various guilds (e.g. nesting on the ground, in shrubs, sub-canopy, or canopy; foraging in leaf litter, on bark, on shrub or tree foliage; nesting on or near the ground, in shrubs, or in the canopy; etc.), making them highly responsive to changes in forest structure and composition and, therefore, a great group to monitor in association with various forest management practices. Over 20 of these species are on the list of Species in Greatest Need of Conservation (SGNC) for Illinois. There are additional species of raptors and wading birds that are on the SGNC and also associate with the various types of forest being managed.

There are a number of attributes of forest songbirds that make them particularly well suited for studying responses to forest management. One is that most if not all of these species are territorial during the breeding season and their territory sizes are typically between 1-3 acres in size. Therefore local forest management activities done at scales of 1, 5, 10, 50, or 100 acres are all highly relevant to these birds that occupy a relatively small area throughout

the breeding season. Another attribute of songbirds is that several species are known to return the next breeding season to places where they reproduced successfully, and to move away from those areas where they failed to reproduce. This behavior tends to lead to an increase in densities in the “better” habitats and a decrease in densities in the “poorer” habitats. In this regard, relative densities are a good predictor of habitat quality with densities being highest in the best habitats. These two attributes in combination should make the songbirds highly responsive to the various types of forest management being done, and changes in their densities will tell us whether the forest management is having a positive, negative, or neutral effect on their local populations.

There is a large body of literature associated with the effects of habitat loss and fragmentation (forest loss and fragmentation here) on populations of breeding forest songbirds. In general, species diversity and the densities of some “area sensitive” species tend to decrease with decreasing forest tract size. In addition, rates of nest predation and cowbird parasitism tend to be higher in small tracts of forest and in landscapes where the forests are more highly fragmented by permanent non-forest land uses. These patterns have been well documented in Midwestern forests. Forests with a mosaic of habitat (e.g. forests where disturbance – either natural or management related – creates structural and compositional complexity) tend to have higher songbird species diversity than a similarly-sized forest lacking disturbance. In addition, disturbances within the forest, as long as they do not remain non-forest permanently, tend to have little or no long-term negative effect on rates of nest predation and cowbird parasitism.

Much of what we know about habitat requirements and habitat use in songbirds comes from observational studies documenting attributes of the forest where songbirds set up their

territories. This has led to recommendations to manage forests for songbirds by achieving a particular tree species composition or vegetation structure and complexity, but the actual responses of the songbirds to the management have usually not been measured. There have been some studies that have documented songbird responses to various kinds of silvicultural practices, but relatively few have had a research design that included a before-after-treatment-control approach. We will now be getting some before-and-after data as we have been sampling non-managed units that have recently been managed or are going to be managed in the near future, particularly at Trail of Tears and Forbes. The data on songbird responses to different types of forest management (e.g. prescribed fire, thinning, re-forestation, etc.) being collected as part of the Forests and Woodlands Campaign will add valuable and much needed information to the vast songbird literature. In addition, in the next few years we hope to determine which species of songbirds respond positively to forest management in parallel with positive responses of wild turkeys to the same management. In this way, there may be several species of breeding forest songbirds that could serve as indicators of higher and lower quality forest habitat for wild turkeys (and possibly also animals “caught” by the camera traps).

Locations to Monitor Wildlife Responses to Forest Management

Monitoring will continue with Segment 9 of the Forest and Woodlands Campaign at all of these sites in Illinois. These sites were selected based on the potential for there to be, at each site, multiple units or plots that are going to be or are being managed (treatments) as well as areas that are not being managed (controls). A goal is to have, at each site, a number of replicates each of treatment and control points. With another couple of years of data we will be able to begin assessing the longer-term effects of the thinning and prescribed fire. We have continued collecting data from Trail of Tears State Forest in an area that is the focus of a

management plan that was implemented beginning fall of 2014, Siloam Spring has greatly increased management efforts beginning in 2015, and the other sites continue to complete ongoing forest management efforts. These areas all have the capacity for monitoring wildlife responses to forest management (i.e. a before-after-treatment-control monitoring protocol). Ramsey Lake State Recreation Area may be added to Segment 9

In addition, all of these various sites are situated in landscapes dominated by or containing a fair amount of non-forest land-use. As such, the relative amounts of forest in the surrounding landscape can vary considerably from site to site. This provides us with the potential to look at not only local effects (e.g. the effects of forest management) on populations of our target species, but also the effects of habitat configuration (e.g. amount of forest cover present) at larger spatial scales (e.g. 2-km radius). In order to maximize the effectiveness of our monitoring protocols, we will work closely and continue to communicate regularly with site managers and staff, biologists, and foresters associated with these locations.

Additional Monitoring Techniques

Game/Trail Camera Deployment. To evaluate the mesocarnivore nest predator and other animal community at Lake Shelbyville, Trail of Tears and Forbes, we conducted camera-trap surveys during April/May 2018. Results are presented in Figures 21-23 based on sampling two management categories as well as non-managed areas at each site. Among the species detected at Lake Shelbyville, we found that deer, squirrels, birds and raccoons were the most commonly “trapped” animals (Figure 21). Based on the camera-trap data, deer were much more prevalent in the non-managed parts of the forest, squirrels more prevalent in the recently burned areas, and raccoons relatively ubiquitous. The potential nest predators (e.g. raccoon

and chipmunk) were not more prevalent in the managed areas of the forest. At Trail of Tears, capture rates were much lower overall than at Lake Shelbyville (Figure 22). None of the potential nest predators (e.g. raccoon and chipmunk) showed an increase prevalence (based on camera-trap data) in the managed areas of the forest. Deer and Wild Turkey both seemed to respond favorably to the recent harvest that had occurred. At Forbes, a greater diversity of animals were camera-trapped than at the other two sites (Figure 23). The more common animals detected at the site were more prevalent in the managed forest areas, particularly where TSI had occurred. These included potential nest predators (e.g. chipmunk, raccoon and opossum) as well as deer, Wild Turkeys and squirrels. The less commonly camera-trapped animals tended to occur mostly in non-managed forests. These findings suggest that the response of potential nest predators to forest management is site specific (e.g. respond favorably at Forbes but not the other two sites), and that the TSI at Forbes in particular may be attractive to some species who may on occasion prey on a bird nest.

Vegetation Surveys. Vegetation surveys were completed at approximately half of all survey points and the data are being added to the ever growing vegetation database. These vegetation surveys will continue to be redone in subsequent years to track changes over time. Differences in vegetation structure and composition are likely the drivers of differences in bird species composition and abundance among management categories at each site during the breeding season as pointed out above in the results narratives for Oakwood Bottoms, Trail of Tears and Lake Shelbyville (Tables 7-9).

Nightjar Surveys. Nightjar (Chuck-Will's-Widows and Eastern Whip-Poor-Wills) surveys were conducted two times (in late April and early June) each at Trail of Tears (10 locations), Forbes (10 locations), and Hidden Springs (10 locations) during the 2018 breeding season. We

included playback of both Whips and Chucks songs at each survey location. At Trail of Tears there were no detections of any nightjars. At Hidden Springs, there was one Eastern Whip-Poor-Will detected briefly at one of the points. At Forbes, Eastern Whip-Poor-Wills (7 individuals) were detected at 6, and Chuck-Will's-Widows (1 individual) at 1, of the 10 locations surveyed. This is a pretty dramatic reduction in detections of Chuck-Will's-Widows at Forbes compared to last year where 14 individuals were detected at 9 of 21 locations surveyed. We will see with further monitoring whether the number of Chuck-Will's-Widows rebounds. Regardless, Forbes continues to have some of the highest densities of breeding nightjars in Illinois likely because of the forest management (much burning and midstory thinning) opening up the forest understory and promoting nightjar populations. These surveys will be continued in Segment 9 and we may add Ramsey Lake as an additional site for Nightjar surveys as it is a site with a forest management history very similar to that of Forbes.

Establishment of Demonstration Sites

Oakwood Bottoms has an ongoing forest management plan involving fire and thinning to promote oak regeneration and a return to an oak-dominated forest composition. Oakwood Bottoms also has multiple units or plots that are going to be or are being managed (treatments) and also has areas that are not being managed (controls), allowing for a true assessment of how the management is affecting both the forest and wildlife. Multiple management units now exist at Trail of Tears State Forest (management began fall of 2014) and these units include "control" areas where no management will occur and management areas (e.g. prescribed fire followed by thinning, thinning followed by prescribed fire, limited harvest, etc.). Forbes, Hidden Springs, Siloam Springs, and Lake Shelbyville all can also serve as superb demonstration areas where the process and results of forest management can easily be shown to interested

constituencies. Forbes is an exceptional venue for highlighting what several years of prescribed fire can achieve in terms of forest plant species composition and structure, and now with some tree thinning taking place, the site is even more valuable as a demonstration area.

Ultimately, our goal for the Forests and Woodlands Campaign in Illinois is to contribute substantially to the growing body of research associated with the effects of forest management on populations of wildlife, and to use the data collected in Illinois to reinforce existing or establish new approaches to forest management that are applicable to forests throughout Illinois and other states in the Midwest.

(iv) Additional Pertinent Information

Additional grant segments will focus on continuing to monitor the response of the forest wildlife to management activities, expand upon some monitoring protocols (e.g. nightjars), measure changes in the various aspects of the vegetation (e.g. forest structure and composition) at survey points, and work with partners to use study sites as demonstration areas that highlight successful forest management techniques and actions. Efforts to develop sophisticated models to account for the non-static nature of forest management (e.g. some forest units experience the same or varied management treatments in each of several years) are underway, and sites will be repeatedly monitored over time as additional forest management is completed in the coming years. As additional analyses are completed, new information will be passed along to agency and site administrators and managers.

(v) Significant Developments

Not Applicable

(vi) Executive Summary

a) We continued to document the responses of breeding birds to forest management (prescribed fire and/or thinning) at over 400 point count locations distributed among 5 study sites.
b) In general, at most sites, a majority of breeding bird species show a positive, neutral or mixed response to forest management supporting the conclusion that forest management designed to benefit the vegetation structure and composition in the forest is also providing tangible benefits (or, at least limited costs) to several breeding bird species, including a number that are on the Illinois Species in Greatest Need of Conservation list.
c) Some ground- and shrub-nesting, and ground-foraging bird species are less abundant immediately (i.e. the very next breeding season) following management of forests with prescribed fire, but the negative effects seem to be relatively short-lived and abundances typically recover within a couple of years post-burn.
d) Brown-headed Cowbird abundances vary by study site and year, but tend **not** to be positively affected by forest management.
e) Vegetation Surveys were conducted at half of all of the point count locations at 3 of the sites (when possible) and vegetation parameters will be monitored over time to assess the effects of forest management on those parameters and how vegetation parameters shape breeding bird diversity and relative abundance in managed forests.
f) Camera traps baited with scent discs at 3 of the study sites documented a wide variety of animals are captured at camera traps and responses (i.e. rate of being captured by cameras) of individual species to forest management is not necessarily consistent. Response of potential nest predators to forest management is site specific (e.g. respond favorably at Forbes but not the other two sites), and the TSI at Forbes in particular may be attractive to some species who may on occasion prey on a bird nest.
g) Nightjars (particularly Eastern Whip-Poor-Wills this year) are very abundant at the Forbes site where there has been a long history of using prescribed fire and midstory thinning to maintain a

forest with an open understory and some exposed ground. Forbes may serve as a showcase for how to manage a forest to promote use by Eastern Whip-Poor-Wills and Chuck-Wills-Widows.

h) Additional grant segments for the Forest and Woodlands Campaign will focus on continuing to monitor the response of the forest wildlife to management activities, expand upon some monitoring protocols (e.g. nightjars), measure changes in the various aspects of the vegetation (e.g. forest structure and composition) at survey points at all sites, and work with partners to use study sites as demonstration areas that highlight successful forest management techniques and actions.

Table 1. Study sites, and number of points surveyed in various management types during Segment 8 of the Forest Campaign (2018).

Location	Management*	Points Surveyed	Replicates
Oakwood Bottoms (Shawnee National Forest)	No Management	10	2
	TSI >4ya	17	2
	TSI <4ya	20	2
	TSI >4ya, Rx Fire >4ya	50	2
	TSI <4ya, Rx Fire >4ya	14	2
	TSI <4ya, MR '18	6	2
Lake Shelbyville (U.S. Army Corp of Engineers land and some IDNR land)	No Management	47	2
	Rx Fire >5 years ago	20	2
	TSI >5 years ago	28	2
	Rx Fire >5 years ago; TSI >5 years ago	20	2
	Rx Fire <5 years ago; TSI >5 years ago	31	2
	Spray '18, Rx Fire '17; TSI >5 years ago	15	2
	Spray '18; Rx Fire '18	22	2
Trail of Tears State Forest	No Management	35	2
	Rx Fire '18, '14	16	2
	Rx Fire '18, '17, '15	17	2
	Rx Fire '18; Harvest '17	15	2
Stephen A. Forbes State Recreation Area	No Management	10	2
	Rx Fires to '16	8	2
	Rx Fires to '17	10	2
	Rx Fires to '17, TSI '16	5	2
	Rx Fires to '18	30	2
	Rx Fires to '18, TSI '16	8	2
Siloam Springs State Park	No Management	4	1
	Rx Fire '17	5	1
	Rx Fire '18	9	1
	TSI >5 years ago; Rx Fire '18, '16	8	1
	TSI <4 years ago; Rx Fire '17, '15	16	1

* Rx Fire = prescribed fire; TSI/FSI = Timber/Forest Stand Improvement (e.g. thinning); Spray = aerial application to remove invasive shrubs (e.g. bush honeysuckle); Harvest = limited single-tree selection.

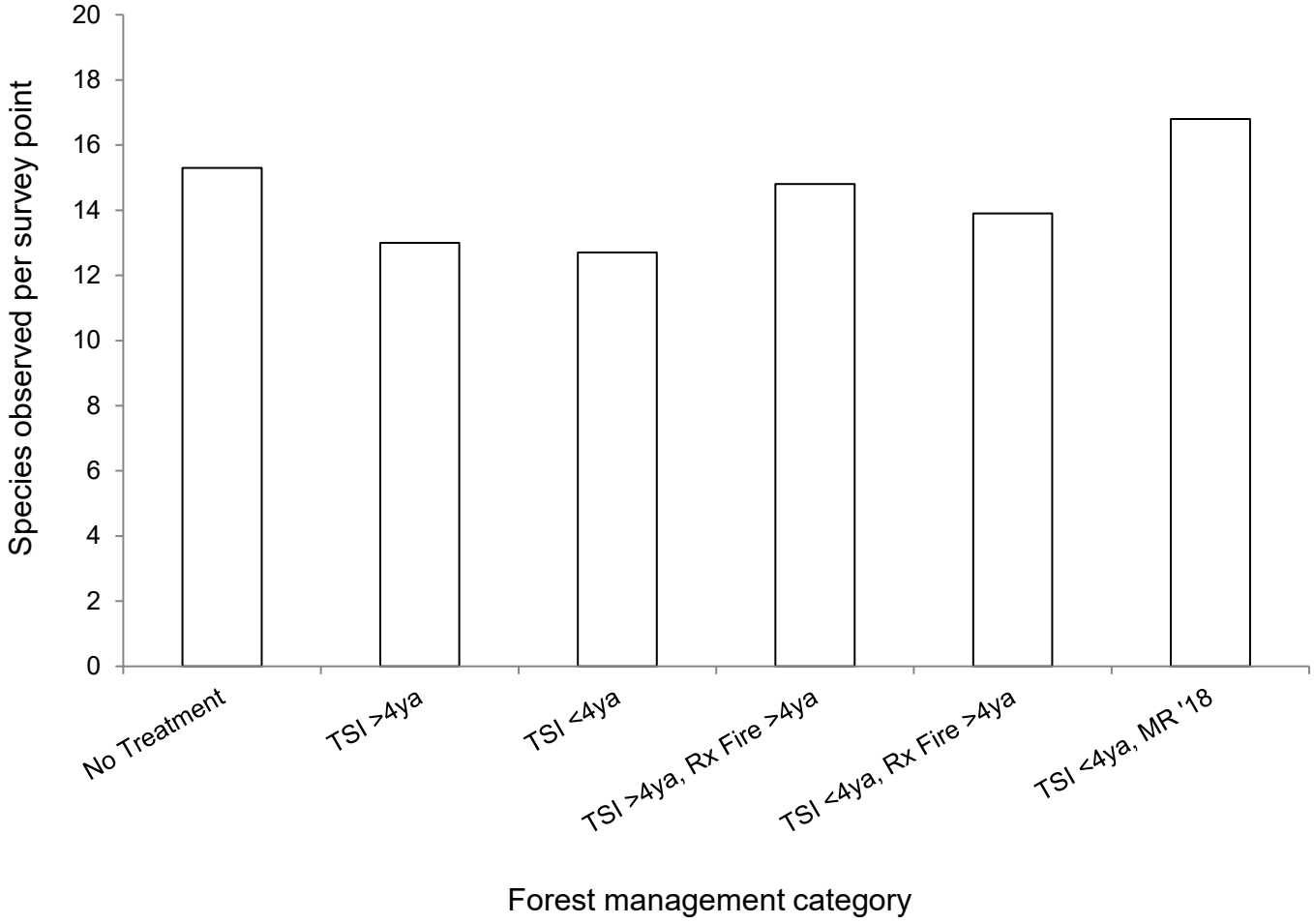

Figure 1. Index of species diversity (mean number of species observed per 100-m-radius survey point) compared among forest treatment categories at **Oakwood Bottoms** during the 2018 breeding season. See Table 1 for number of survey points per category and description of management. Overall differences were not significant (F=1.753, df=5, 111, P=0.13).

Table 2. Results of bird surveys completed during the 2018 breeding season at Oakwood Bottoms (U.S. Forest Service), Illinois. Species ranked from most to least abundant based on total point counts. Values represent number of individuals seen per point (averaged for 2 visits to each point) averaged across points within each category.

		Number per 100-m radius point						
		Management***						
Species Code*	Species**	TSI >4ya (17)	TSI <4ya (20)	TSI >4ya, Rx Fire >4ya (50)	TSI <4ya, Rx Fire >4ya (14)	TSI <4ya, MR '18 (6)	NONE (10)	Total (n=123)
ACFL(-)	***Acadian Flycatcher***	1.91	1.90	1.61	0.71	1.33	2.50	1.70
NOPA(-)	Northern Parula	0.91	1.05	1.10	0.54	1.00	0.90	0.96
COYE(+)	Common Yellowthroat	0.68	1.23	0.82	1.21	0.67	0.40	0.88
YBCU(-)	***Yellow-billed Cuckoo***	0.97	0.65	0.92	0.50	0.83	0.90	0.83
INBU(-)	Indigo Bunting	0.71	0.25	1.05	0.86	0.50	0.80	0.81
WEVI(+)	White-eyed Vireo	0.59	0.73	0.95	0.71	0.58	0.25	0.77
TUTI(-)	Tufted Titmouse	1.00	0.45	0.67	0.39	0.67	1.20	0.77
REVI(-)	Red-eyed Vireo	0.88	0.53	0.67	0.54	0.67	1.35	0.73
PROW(+)	Prothonotary Warbler	0.56	0.93	0.68	0.43	0.75	0.40	0.66
AMCR(+)	American Crow	0.59	0.78	0.38	0.39	0.92	0.45	0.59
EAWP(-)	Eastern Wood Peewee	0.65	0.58	0.51	0.46	0.33	0.65	0.54
BGGN(+)	Blue-gray Gnatcatcher	0.47	0.43	0.52	0.64	0.67	0.30	0.51
NOCA(+)	Northern Cardinal	0.68	0.25	0.64	0.25	0.17	0.20	0.49
CARW(- +)	Carolina Wren	0.26	0.50	0.45	0.21	0.83	0.45	0.42
KEWA(- +)	***Kentucky Warbler***	0.53	0.65	0.34	0.04	0.00	0.40	0.39
BHCO(-)	Brown-headed Cowbird	0.29	0.28	0.50	0.29	0.33	0.45	0.38
AMRE(+)	American Redstart	0.24	0.88	0.33	0.11	0.33	0.00	0.36
RBWO(-)	Red-bellied Woodpecker	0.32	0.23	0.37	0.36	0.33	0.50	0.35
YBCH(+)	***Yellow-breasted Chat***	0.18	0.45	0.39	0.64	0.08	0.05	0.35
EATO(+)	Eastern Towhee	0.62	0.33	0.21	0.50	0.42	0.05	0.31
GCFL(- +)	Great Crested Flycatcher	0.09	0.25	0.31	0.32	0.67	0.40	0.28
WBNU(-)	White-breasted Nuthatch	0.15	0.28	0.37	0.11	0.33	0.25	0.27
RHWO(+)	***Red-headed Woodpecker***	0.06	0.40	0.03	1.18	0.33	0.15	0.26
DOWO(-)	Downy Woodpecker	0.15	0.25	0.23	0.11	0.25	0.35	0.21
HAWO(+)	Hairy Woodpecker	0.24	0.25	0.04	0.14	0.67	0.05	0.16
CACH(-)	Carolina Chickadee	0.06	0.00	0.23	0.00	0.00	0.20	0.13
YTWA(+ -)	Yellow-throated Warbler	0.00	0.08	0.25	0.07	0.00	0.05	0.13
MODO(-)	Mourning Dove	0.06	0.08	0.13	0.14	0.00	0.30	0.12
SUTA(-)	Summer Tanager	0.12	0.08	0.11	0.11	0.00	0.30	0.11
PIWO(+)	Pileated Woodpecker	0.09	0.15	0.16	0.04	0.00	0.00	0.11
YEWA(+)	Yellow Warbler	0.06	0.23	0.07	0.07	0.00	0.00	0.10
RSHA	***Red-shouldered Hawk***	0.18	0.03	0.07	0.07	0.08	0.15	0.09
FICR	Fish Crow	0.00	0.03	0.18	0.04	0.00	0.05	0.09
YTVI	Yellow-throated Vireo	0.06	0.05	0.16	0.00	0.08	0.00	0.09
RTHU	Ruby-throated Hummingbird	0.03	0.10	0.11	0.07	0.00	0.05	0.08
BLJA	Blue Jay	0.18	0.00	0.02	0.07	0.17	0.25	0.07
RWBL	Red-winged Blackbird	0.00	0.25	0.03	0.00	0.25	0.00	0.07
WEWA	***Worm-eating Warbler***	0.03	0.05	0.02	0.25	0.00	0.00	0.05
BADO	Barred Owl	0.00	0.05	0.10	0.00	0.00	0.00	0.05
WOTH	***Wood Thrush***	0.09	0.00	0.08	0.00	0.00	0.00	0.04
SCTA	Scarlet Tanager	0.00	0.08	0.00	0.00	0.00	0.00	0.03
AMGO	American Goldfinch	0.00	0.05	0.01	0.00	0.00	0.05	0.02
GRCA	Gray Catbird	0.00	0.08	0.01	0.00	0.00	0.00	0.02
EAKI	Eastern Kingbird	0.00	0.00	0.03	0.00	0.00	0.00	0.01
EAPH	Eastern Phoebe	0.00	0.00	0.00	0.00	0.17	0.05	0.01
FISP	***Field Sparrow***	0.00	0.00	0.03	0.00	0.00	0.00	0.01
RBGR	Rose-breasted Grosbeak	0.06	0.00	0.00	0.00	0.08	0.00	0.01
AMRO	American Robin	0.00	0.00	0.02	0.00	0.00	0.00	0.01
BRCR	***Brown Creeper***	0.00	0.00	0.02	0.00	0.00	0.00	0.01
BRTH	Brown Thrasher	0.00	0.00	0.02	0.00	0.00	0.00	0.01
CHSP	Chipping Sparrow	0.00	0.00	0.01	0.04	0.00	0.00	0.01
EABL	Eastern Bluebird	0.00	0.00	0.01	0.00	0.00	0.05	0.01
GBHE	Great Blue Heron	0.03	0.00	0.01	0.00	0.00	0.00	0.01
BWHA	***Broad-winged Hawk***	0.00	0.00	0.00	0.04	0.00	0.00	0.00
NOFL	***Northern Flicker***	0.03	0.00	0.00	0.00	0.00	0.00	0.00
SNEG	Snowy Egret	0.00	0.00	0.00	0.04	0.00	0.00	0.00
WAVI	Warbling Vireo	0.00	0.00	0.01	0.00	0.00	0.00	0.00
WITU	***Wild Turkey***	0.00	0.00	0.01	0.00	0.00	0.00	0.00

* (+) = positive, (-) = negative, and (+ -) = mixed response of relative abundance to management.

** Species on the Species in Greatest Need of Conservation (SGNC) list are given in bold and italics.

*** Rx Fire = prescribed fire; TSI = Timber Stand Improvement (e.g. thinning); MR = mid-story removal. Parenthetical () is number of points.

= species that were more abundant (>0.20) overall and responded to forest management.

= species that were less abundant (0.10-0.20) overall and responded to forest management.

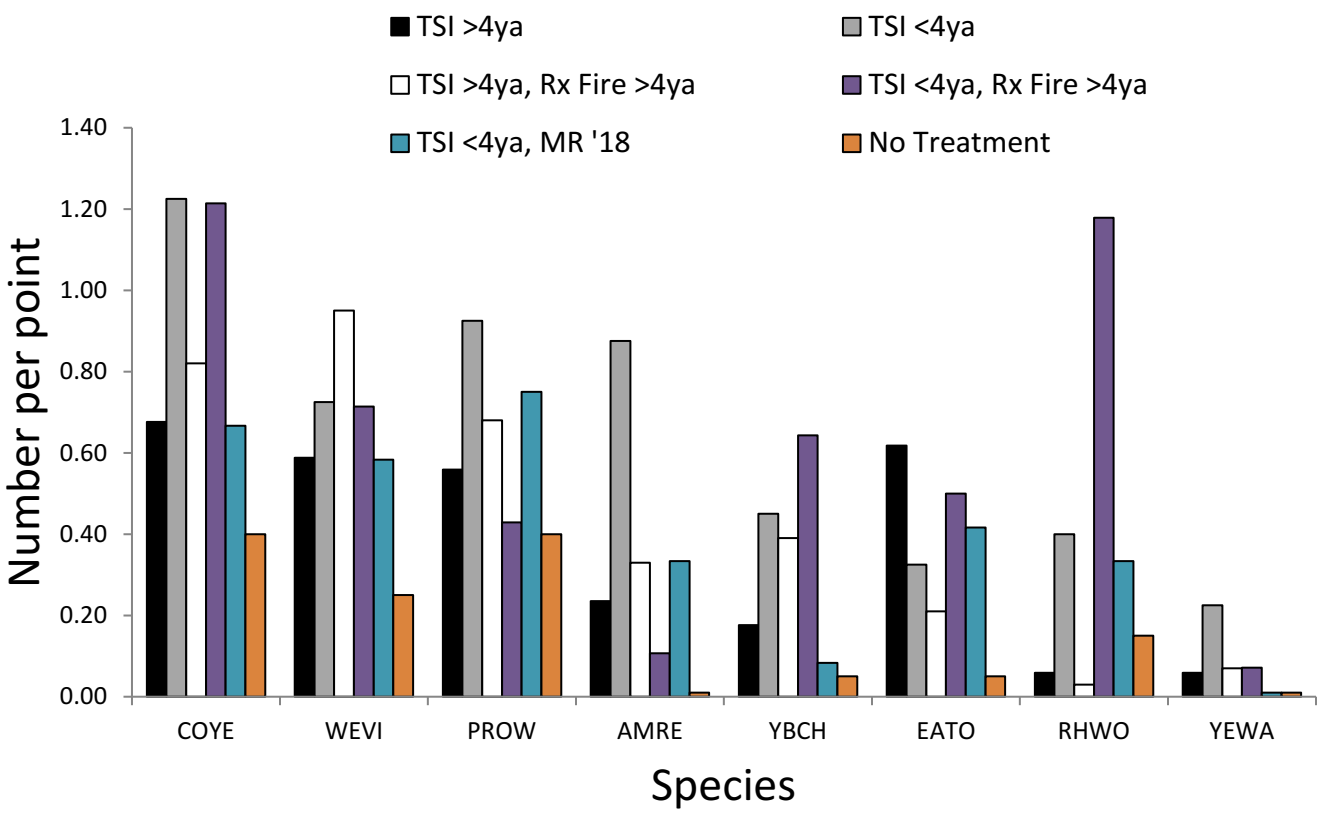

Figure 2. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Oakwood Bottoms** during the 2018 breeding season showing **positive** responses to different types of forest management. Species codes and types of management defined in species table for this site.

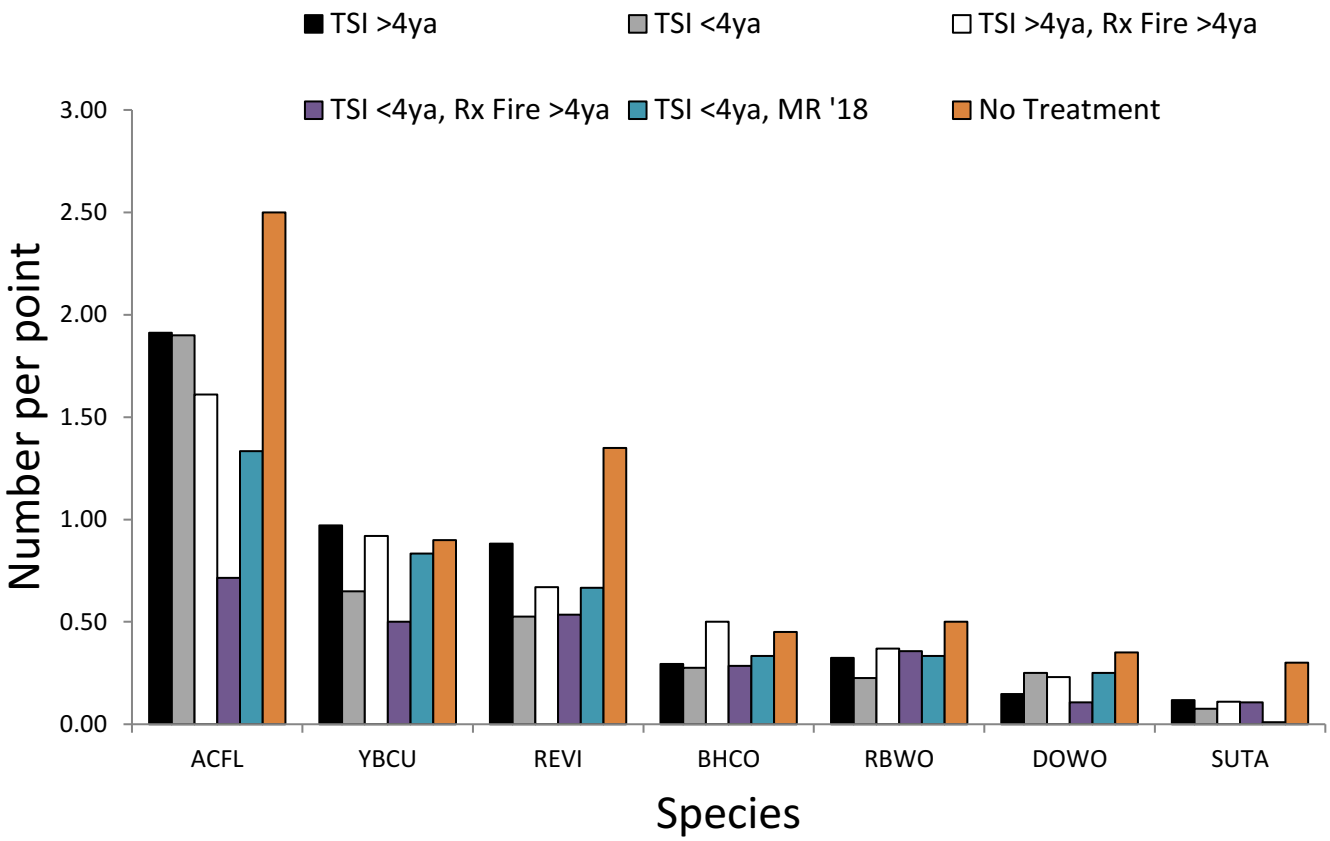

Figure 3. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Oakwood Bottoms** during the 2018 breeding season showing **negative** responses to different types of forest management. Species codes and types of management defined in species table for this site.

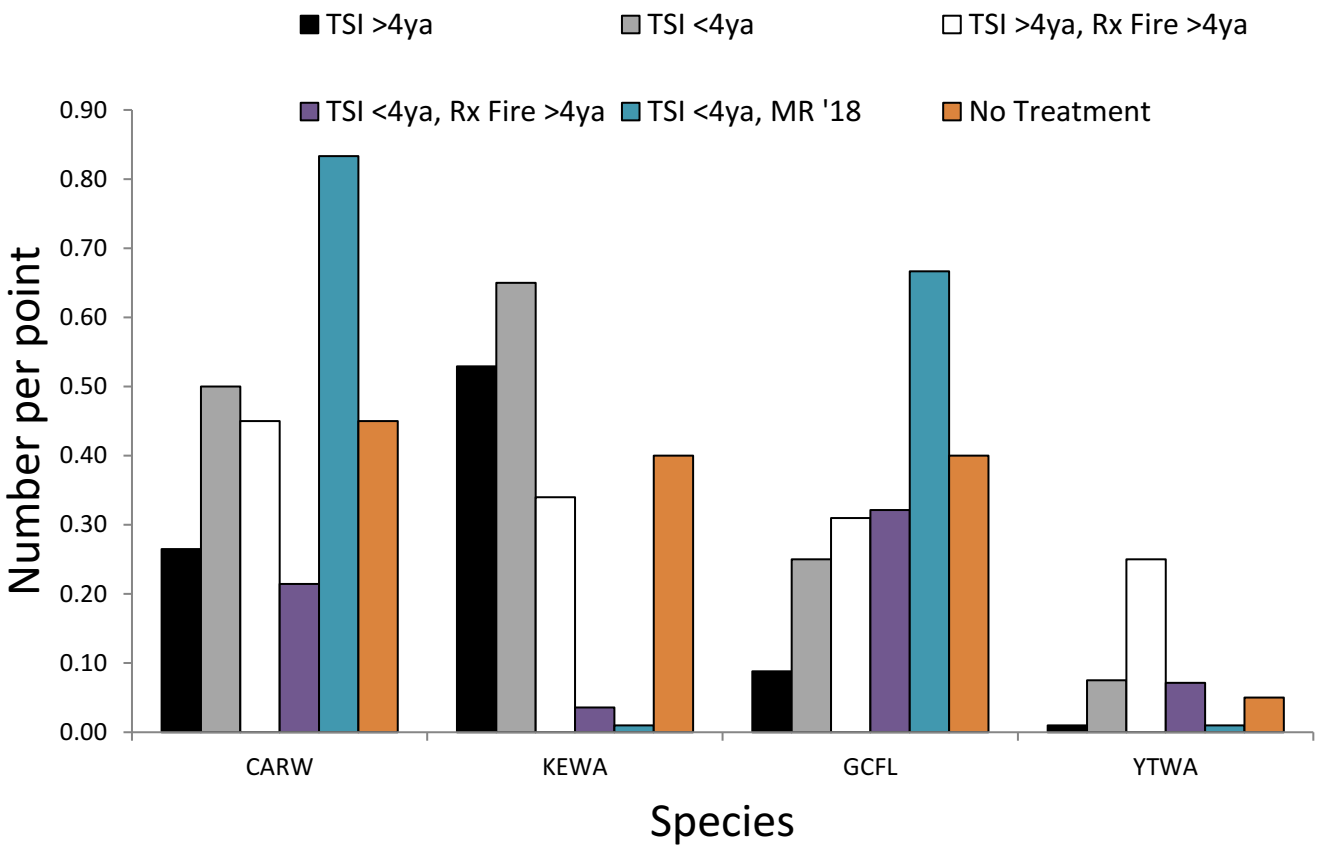

Figure 4. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Oakwood Bottoms** during the 2018 breeding season showing **mixed** responses to different types of forest management. Species codes and types of management defined in species table for this site.

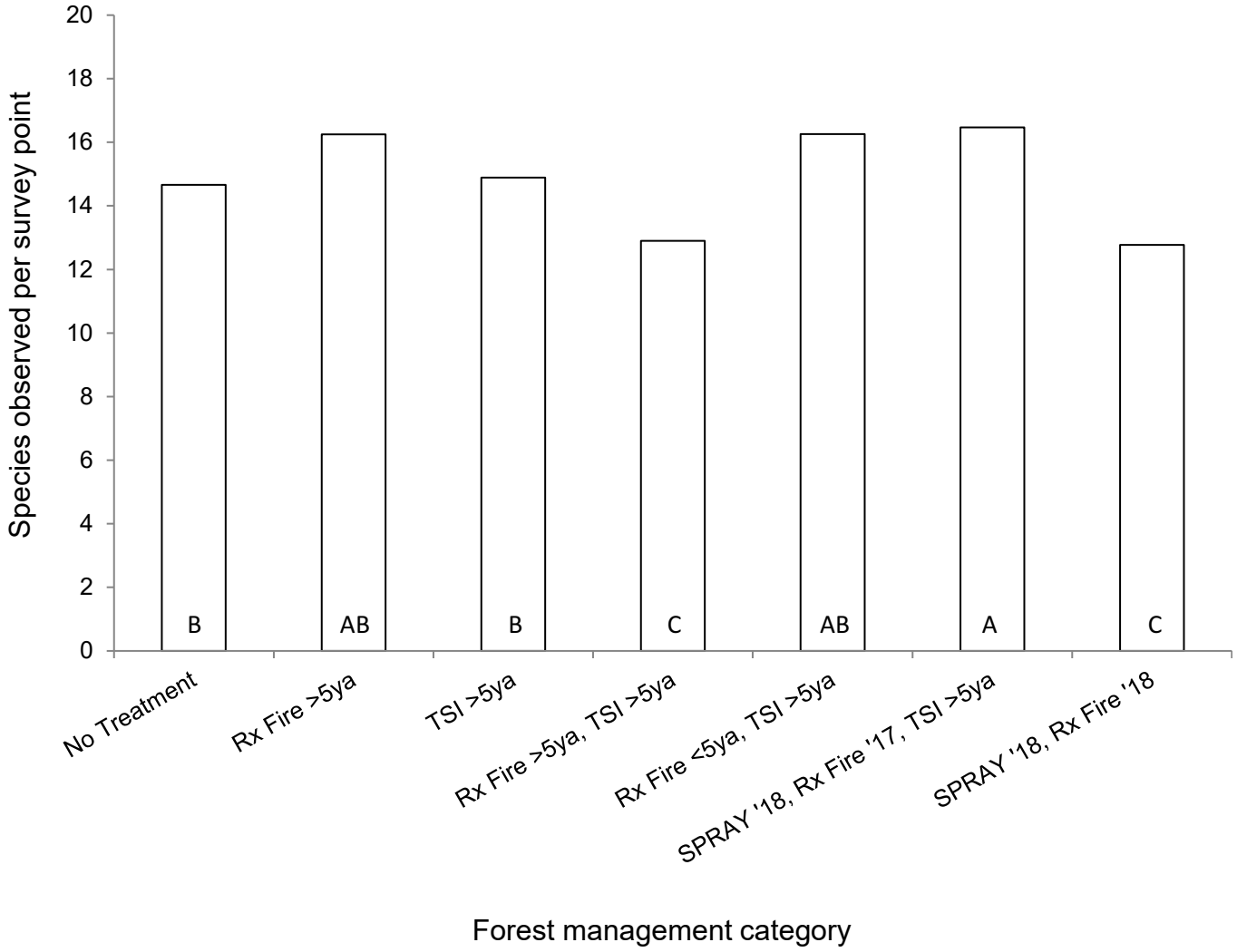

Figure 5. Index of species diversity (mean number of species observed per 100-m-radius survey point) compared among forest treatment categories at **Lake Shelbyville** during the 2018 breeding season. See Table 1 for number of survey points per category and description of management. Overall differences were significant (F=3.94, df=6, 176, P=0.001). Categories with the same letter are not different from each other.

Table 3. Results of bird surveys completed during the 2018 breeding season at Lake Shelbyville - U.S. Army Corp of Engineers, Illinois. Species ranked from most to least abundant based on total point counts.
Values represent number of individuals seen per point (averaged for 2 visits to each point) averaged across points within each category.

		Number per 100-m radius point							
		Management***							
Species Code*	Species**	Rx Fire >5ya (20)	TSI >5ya (28)	Rx Fire >5ya, TSI >5ya (20)	Rx Fire <5ya, TSI >5ya (31)	SPRAY '18, Rx Fire '17, TSI >5ya (15)	SPRAY '18, Rx Fire '18 (22)	NONE (47)	Total (n=219)
TUTI(-)	Tufted Titmouse	1.10	0.68	0.95	0.85	1.17	0.89	1.49	1.10
EAWP(+-)	Eastern Wood Peewee	1.18	0.93	0.68	1.44	1.43	0.93	1.01	1.03
AMRO(+)	American Robin	0.50	1.09	0.55	0.94	0.97	0.43	0.55	0.77
BLJA(+-)	Blue Jay	0.58	0.89	0.45	0.89	1.17	0.64	0.72	0.77
NOCA(-)	Northern Cardinal	0.90	1.04	0.33	0.66	0.50	0.64	0.87	0.76
WBNU(+)	White-breasted Nuthatch	0.55	0.48	0.58	0.95	0.80	0.75	0.54	0.66
RBWO(+-)	Red-bellied Woodpecker	0.55	0.68	0.55	0.73	0.83	0.39	0.54	0.56
CARW(+-)	Carolina Wren	0.65	0.61	0.20	0.84	0.27	0.50	0.51	0.52
BHCO(-)	Brown-headed Cowbird	0.68	0.57	0.68	0.47	0.57	0.30	0.55	0.51
MODO(+-)	Mourning Dove	0.35	0.63	0.13	0.58	0.93	0.39	0.33	0.48
DOWO(+)	Downy Woodpecker	0.25	0.54	0.35	0.65	0.57	0.43	0.38	0.45
YBCU(-)	***Yellow-billed Cuckoo***	0.30	0.50	0.35	0.47	0.30	0.27	0.47	0.44
INBU(+)	Indigo Bunting	0.28	0.30	0.53	0.37	0.33	0.57	0.39	0.41
CHIC	Chickadee Spp.	0.45	0.43	0.18	0.32	0.43	0.50	0.32	0.39
AMCR(+-)	American Crow	0.70	0.20	0.40	0.27	0.17	0.39	0.49	0.39
GCFL(+)	Great Crested Flycatcher	0.25	0.34	0.20	0.61	0.37	0.32	0.35	0.37
WOTH(-+)	***Wood Thrush***	0.20	0.32	0.10	0.18	0.73	0.57	0.53	0.37
EATO(+-)	Eastern Towhee	0.40	0.41	0.38	0.29	0.07	0.16	0.29	0.29
REVI(+-)	Red-eyed Vireo	0.50	0.45	0.15	0.29	0.17	0.18	0.28	0.29
ACFL(-)	***Acadian Flycatcher***	0.48	0.14	0.03	0.11	0.07	0.36	0.60	0.27
BGGN(-)	Blue-gray Gnatcatcher	0.10	0.23	0.30	0.15	0.30	0.30	0.32	0.24
WAVI(+)	Warbling Vireo	0.38	0.18	0.28	0.16	0.50	0.36	0.04	0.22
HAWO(+)	Hairy Woodpecker	0.15	0.23	0.20	0.29	0.30	0.20	0.13	0.19
HOWR(-)	House Wren	0.10	0.02	0.03	0.05	0.03	0.23	0.28	0.15
RWBL(+)	Red-winged Blackbird	0.08	0.34	0.05	0.00	0.07	0.30	0.07	0.15
AMGO(-)	American Goldfinch	0.28	0.07	0.00	0.21	0.23	0.07	0.24	0.15
SUTA(-)	Summer Tanager	0.13	0.14	0.15	0.16	0.03	0.09	0.21	0.15
FISP(-)	***Field Sparrow***	0.18	0.02	0.05	0.13	0.07	0.18	0.22	0.15
NOFL(+)	***Northern Flicker***	0.23	0.21	0.23	0.24	0.40	0.00	0.04	0.14
SCTA(-)	Scarlet Tanager	0.08	0.09	0.13	0.11	0.03	0.16	0.23	0.14
COYE(+-)	Common Yellowthroat	0.13	0.02	0.08	0.05	0.00	0.25	0.10	0.12
SOSP(-)	Song Sparrow	0.00	0.09	0.15	0.02	0.00	0.14	0.15	0.10
KEWA(-)	***Kentucky Warbler***	0.00	0.13	0.03	0.18	0.07	0.09	0.16	0.10
RBGR	Rose-breasted Grosbeak	0.18	0.09	0.13	0.11	0.10	0.02	0.06	0.09
OVEN	***Ovenbird***	0.15	0.11	0.08	0.13	0.00	0.00	0.07	0.08
COGR	Common Grackle	0.13	0.02	0.00	0.00	0.07	0.55	0.00	0.08
GBHE	Great Blue Heron	0.10	0.04	0.10	0.18	0.07	0.11	0.00	0.07
PIWO	Pileated Woodpecker	0.00	0.02	0.15	0.08	0.10	0.05	0.02	0.07
RTHU	Ruby-throated Hummingbird	0.05	0.07	0.00	0.05	0.07	0.05	0.10	0.07
CEDW	Cedar Waxwing	0.05	0.07	0.00	0.02	0.10	0.00	0.10	0.06
GRCA	Gray Catbird	0.03	0.11	0.05	0.02	0.00	0.16	0.04	0.06
CANG	Canada Goose	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
YTVI	Yellow-throated Vireo	0.08	0.00	0.03	0.06	0.00	0.00	0.16	0.05
TRES	Tree Swallow	0.00	0.00	0.13	0.03	0.10	0.14	0.05	0.05
NOPA	Northern Parula	0.00	0.02	0.03	0.02	0.00	0.00	0.06	0.04
RTHA	Red-tailed Hawk	0.00	0.02	0.05	0.02	0.10	0.02	0.03	0.04
CHSP	Chipping Sparrow	0.15	0.02	0.00	0.02	0.00	0.02	0.04	0.03
BARS	Barn Swallow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
BEKI	Belted Kingfisher	0.05	0.00	0.03	0.03	0.07	0.00	0.07	0.03
EAKI	Eastern Kingbird	0.00	0.02	0.00	0.03	0.13	0.05	0.02	0.03
LOWA	Louisiana Waterthrush	0.00	0.04	0.00	0.05	0.10	0.00	0.03	0.03
RHWO	***Red-headed Woodpecker***	0.10	0.00	0.05	0.02	0.03	0.02	0.03	0.03

Table 3 (continued)

		Number per 100-m radius point							
		Management***							
Species Code*	Species**	Rx Fire >5ya (20)	TSI >5ya (28)	Rx Fire >5ya, TSI >5ya (20)	Rx Fire <5ya, TSI >5ya (31)	SPRAY '18, Rx Fire '17, TSI >5ya (15)	SPRAY '18, Rx Fire '18 (22)	NONE (47)	Total (n=219)
EABL	Eastern Bluebird	0.05	0.02	0.03	0.00	0.03	0.05	0.00	0.03
YBCH	***Yellow-breasted Chat***	0.10	0.04	0.00	0.00	0.03	0.00	0.04	0.03
BAOR	Baltimore Oriole	0.00	0.02	0.00	0.03	0.03	0.00	0.02	0.02
BAEA	***Bald Eagle***	0.00	0.04	0.00	0.00	0.17	0.00	0.00	0.02
CHSW	***Chimney Swift***	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.02
KILL	Killdeer	0.08	0.00	0.00	0.02	0.00	0.02	0.00	0.02
EAPH	Eastern Phoebe	0.05	0.00	0.00	0.00	0.00	0.00	0.04	0.02
WEVI	White-eyed Vireo	0.05	0.00	0.00	0.00	0.00	0.00	0.03	0.02
PROW	Prothonotary Warbler	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.01
RSHA	***Red-shouldered Hawk***	0.00	0.00	0.00	0.02	0.03	0.00	0.04	0.01
WITU	***Wild Turkey***	0.05	0.00	0.00	0.02	0.07	0.00	0.01	0.01
TUVU	Turkey Vulture	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01
AMRE	American Redstart	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DICK	Dickcissel	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
HOFI	House Finch	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
OSPR	***Osprey***	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00
YEWA	Yellow-throated Warbler	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
BADO	Barred Owl	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BRTH	Brown Thrasher	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BWHA	***Broad-winged Hawk***	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
HOSP	House Sparrow	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
NOBO	***Northern Bobwhite***	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
WEWA	***Worm-eating Warbler***	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00

* (+) = positive, (-) = negative, and (+ -) = mixed response of relative abundance to management.

** Species on the Species in Greatest Need of Conservation (SGNC) list are given in bold and italics.

*** Rx Fire = prescribed fire; TSI = Timber Stand Improvement (e.g. thinning); SPRAY = aerial application to remove invasive shrubs (e.g. bush honeysuckle). Parenthetical () is number of points.

= species that were more abundant (>0.20) overall and responded to forest management.

= species that were less abundant (0.10-0.20) overall and responded to forest management.

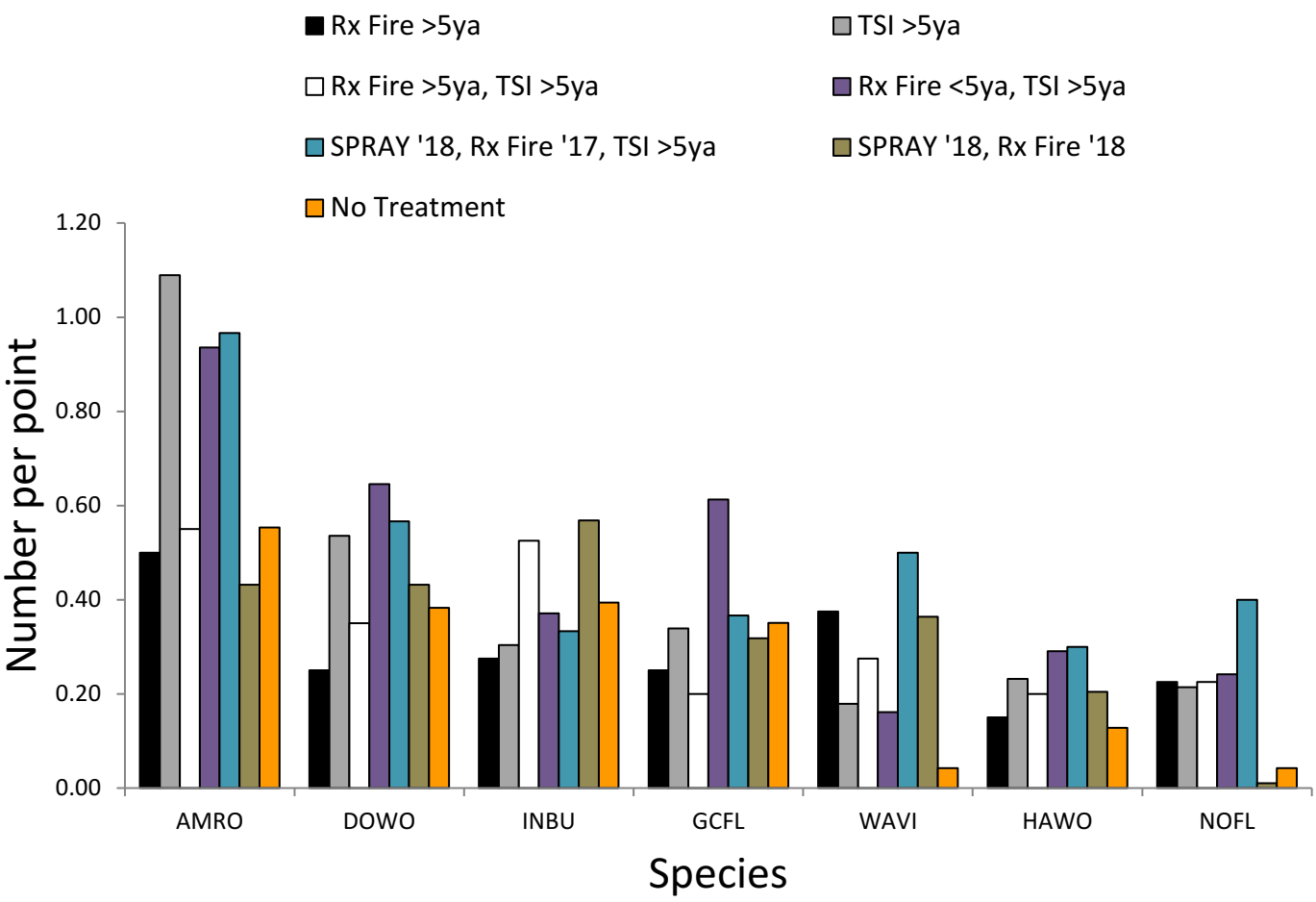

Figure 6. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Lake Shelbyville** during the 2018 breeding season showing **positive** responses to different types of forest management. Species codes and types of management defined in species table for this site.

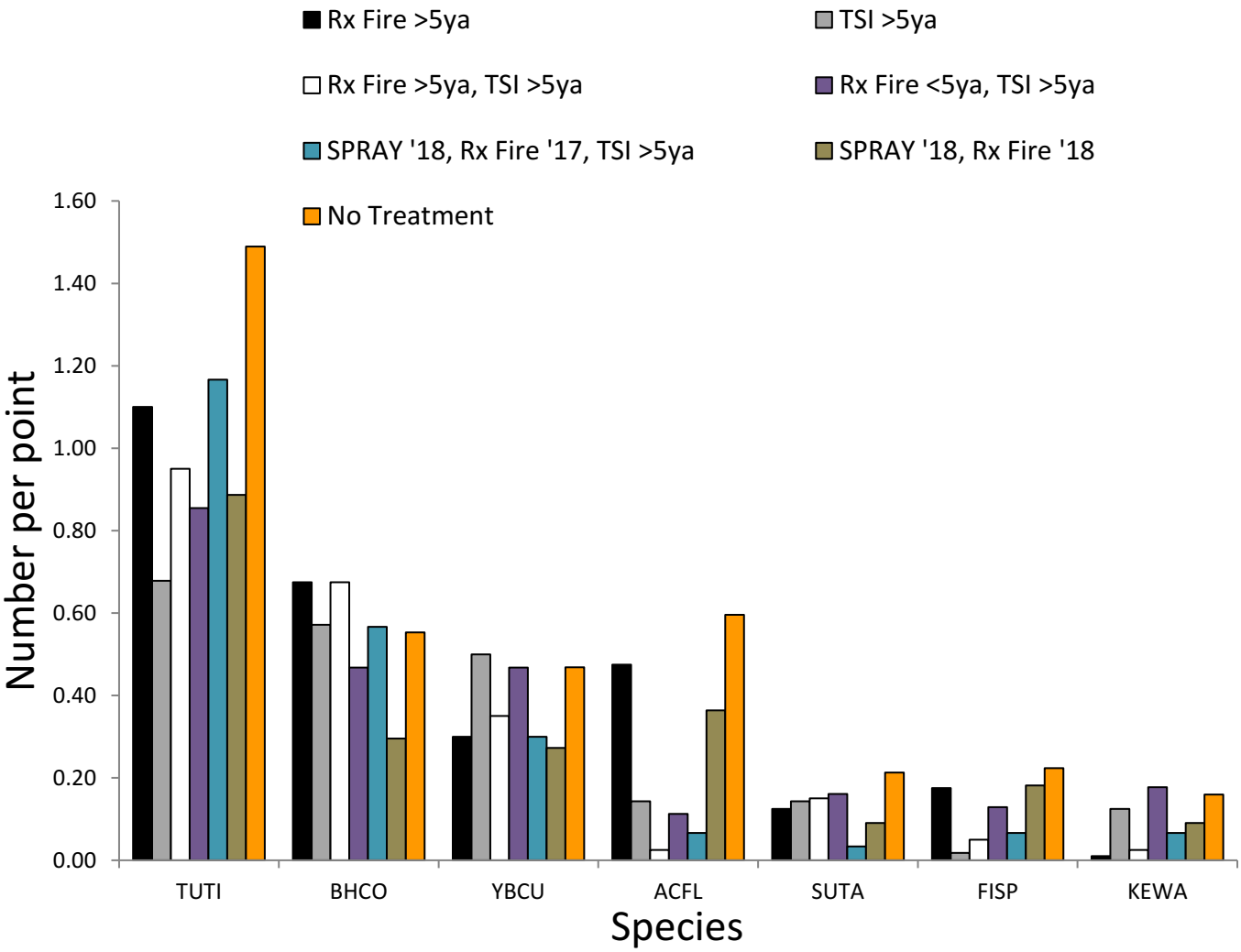

Figure 7. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Lake Shelbyville** during the 2018 breeding season showing **negative** responses to different types of forest management. Species codes and types of management defined in species table for this site.

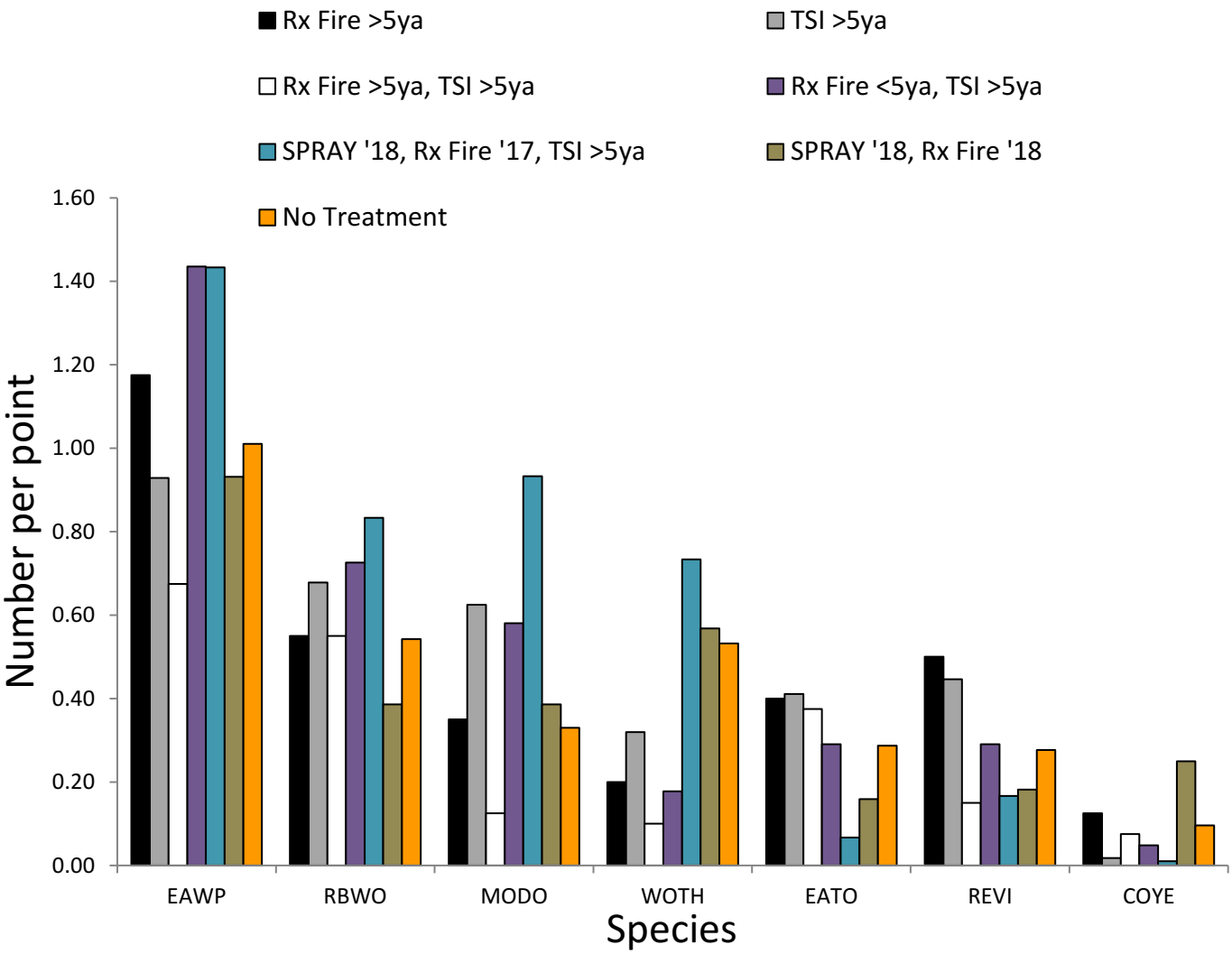

Figure 8. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Lake Shelbyville** during the 2018 breeding season showing mixed responses to different types of forest management. Species codes and types of management defined in species table for this site.

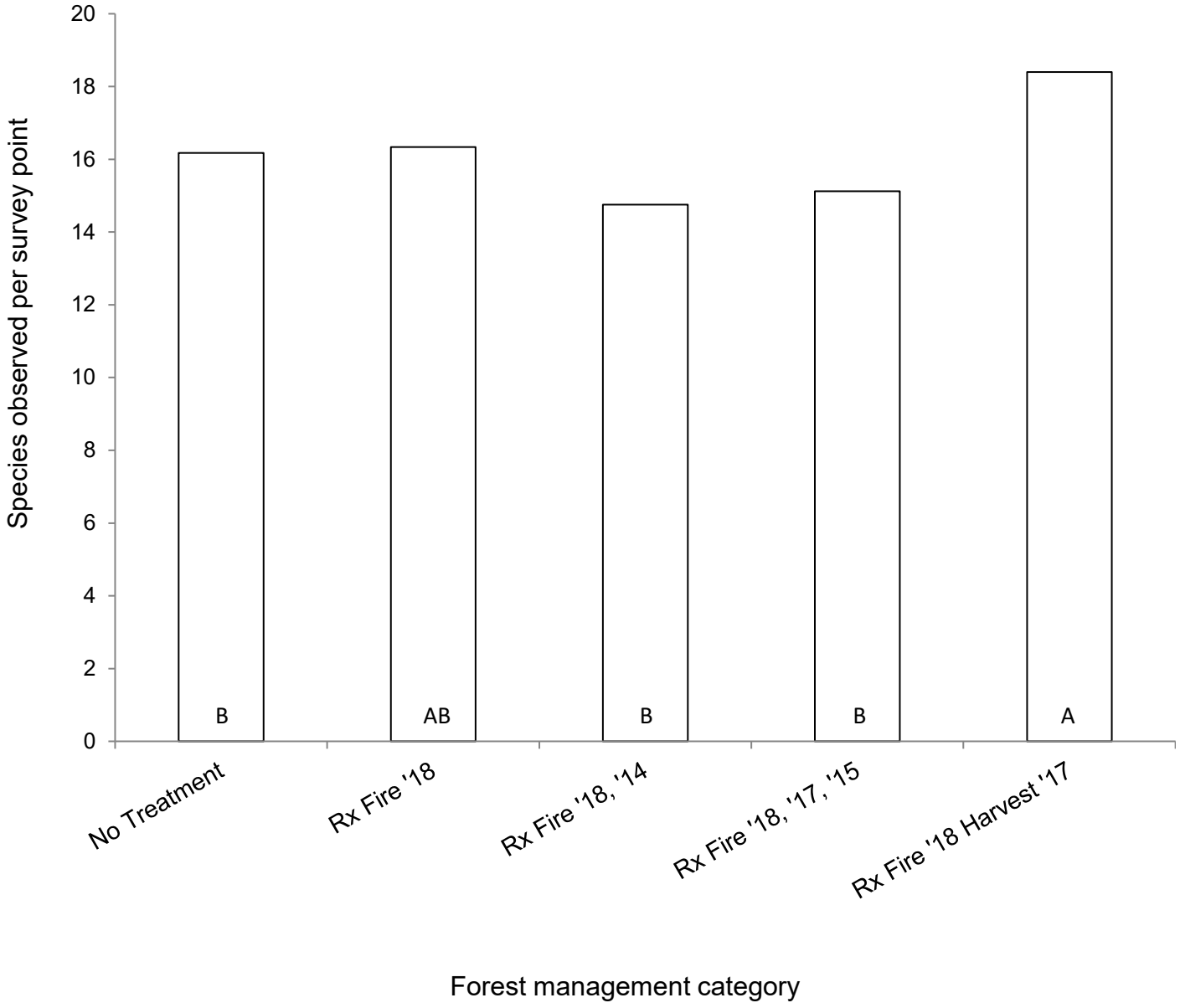

Figure 9. Index of species diversity (mean number of species observed per 100-m-radius survey point) compared among forest treatment categories at **Trail of Tears** during the 2018 breeding season. See Table 1 for number of survey points per category and description of management. Overall differences were significant (F=3.29, df=4, 81, P=0.015). Categories with the same letter are not different from each other.

Table 4. Results of bird surveys completed during the 2018 breeding season at Trail of Tears State Forest, Illinois. Species ranked from most to least abundant based on total point counts. Values represent number of individuals seen per point (averaged for 2 visits to each point) averaged across points within each category.

		Number per 100-m radius point				
		Management***				
Species Code*	Species**	Rx Fire '18, '14 (16)	Rx Fire '18, '17, '15 (17)	Rx Fire '18 Harvest '17 (15)	None (35)	Total (n=86)
ACFL(+)	***Acadian Flycatcher***	2.94	1.91	1.93	1.87	2.11
TUTI	Tufted Titmouse	1.06	1.32	0.97	0.96	1.04
EAWP(+)	Eastern Wood Peewee	1.31	0.79	0.87	0.70	0.89
REVI(+ -)	Red-eyed Vireo	1.16	0.65	0.50	0.83	0.77
BGGN	Blue-gray Gnatcatcher	0.59	0.56	0.67	0.64	0.62
WOTH	***Wood Thrush***	0.59	0.56	0.73	0.57	0.59
BHCO(+ -)	Brown-headed Cowbird	0.41	0.71	0.47	0.56	0.56
CARW(+)	Carolina Wren	0.47	0.62	0.93	0.34	0.55
WBNU	White-breast Nuthatch	0.69	0.47	0.53	0.54	0.55
NOPA	Northern Parula	0.59	0.44	0.53	0.46	0.49
WEWA(-)	***Worm-eating Warbler***	0.44	0.44	0.40	0.60	0.49
RBWO(+)	Red-bellied Woodpecker	0.59	0.59	0.50	0.36	0.48
NOCA(-)	Northern Cardinal	0.28	0.32	0.47	0.44	0.42
GCFL	Great Crested Flycatcher	0.31	0.53	0.30	0.46	0.42
SUTA(+)	Summer Tanager	0.38	0.50	0.40	0.33	0.39
YBCU(-)	***Yellow-billed Cuckoo***	0.53	0.24	0.27	0.44	0.39
MODO(+)	Mourning Dove	0.44	0.21	0.63	0.33	0.38
HOWA(-)	Hooded Warbler	0.06	0.21	0.43	0.39	0.29
KEWA(+)	***Kentucky Warbler***	0.28	0.09	0.53	0.14	0.25
SCTA(-)	Scarlet Tanager	0.13	0.18	0.10	0.37	0.24
LOWA(+)	Louisiana Waterthrush	0.34	0.18	0.23	0.17	0.21
OVEN(-)	***Ovenbird***	0.00	0.12	0.07	0.39	0.20
WEVI(+)	White-eyed Vireo	0.19	0.21	0.33	0.10	0.20
AMCR(-)	American Crow	0.06	0.29	0.00	0.26	0.18
INBU(+)	Indigo Bunting	0.03	0.00	0.70	0.04	0.16
DOWO	Downy Woodpecker	0.13	0.18	0.17	0.13	0.16
CACH(-)	Carolina Chickadee	0.13	0.18	0.03	0.21	0.15
PIWO(+)	Pileated Woodpecker	0.25	0.06	0.20	0.13	0.15
BLJA	Blue Jay	0.16	0.12	0.20	0.09	0.12
HAWO(+)	Hairy Woodpecker	0.22	0.03	0.20	0.06	0.10
CHSP(+)	***Chipping Sparrow***	0.00	0.21	0.13	0.06	0.10
COYE	Common Yellowthroat	0.00	0.03	0.13	0.10	0.08
RTHU	Ruby-throated Hummingbird	0.19	0.00	0.10	0.06	0.08
AMRE	American Redstart	0.00	0.00	0.17	0.07	0.06
YTVI	Yellow-throated Vireo	0.09	0.00	0.03	0.06	0.05
YTWA	Yellow-throated Warbler	0.03	0.15	0.03	0.00	0.05
RSHA	***Red-shouldered Hawk***	0.03	0.03	0.07	0.03	0.03
FISP	***Field Sparrow***	0.00	0.00	0.03	0.03	0.02
EATO	Eastern Towhee	0.00	0.00	0.07	0.00	0.01
TRES	Tree Swallow	0.00	0.06	0.00	0.00	0.01
AMRO	American Robin	0.00	0.00	0.00	0.01	0.01
BRTH	Brown Thrasher	0.00	0.00	0.00	0.01	0.01
CERW	***Cerulean Warbler***	0.00	0.00	0.03	0.00	0.01
EAPH	Eastern Phoebe	0.00	0.00	0.00	0.00	0.01
RBGR	Rose-breasted Grosbeak	0.00	0.03	0.00	0.00	0.01
RWBL	Red-winged Blackbird	0.00	0.00	0.00	0.01	0.01
YBCH	***Yellow-breasted Chat***	0.00	0.00	0.00	0.01	0.01

* (+) = positive, (-) = negative, and (+ -) = mixed response of relative abundance to management.

** Species on the Species in Greatest Need of Conservation (SGNC) list are given in bold and italics.

*** Rx Fire = prescribed fire; FSI = Forest Stand Improvement (e.g. thinning), Harvest = limited single-tree selection. Parenthetical () is number of points.

= species that were more abundant (>0.20) overall and responded to forest management.

= species that were less abundant (0.10-0.20) overall and responded to forest management.

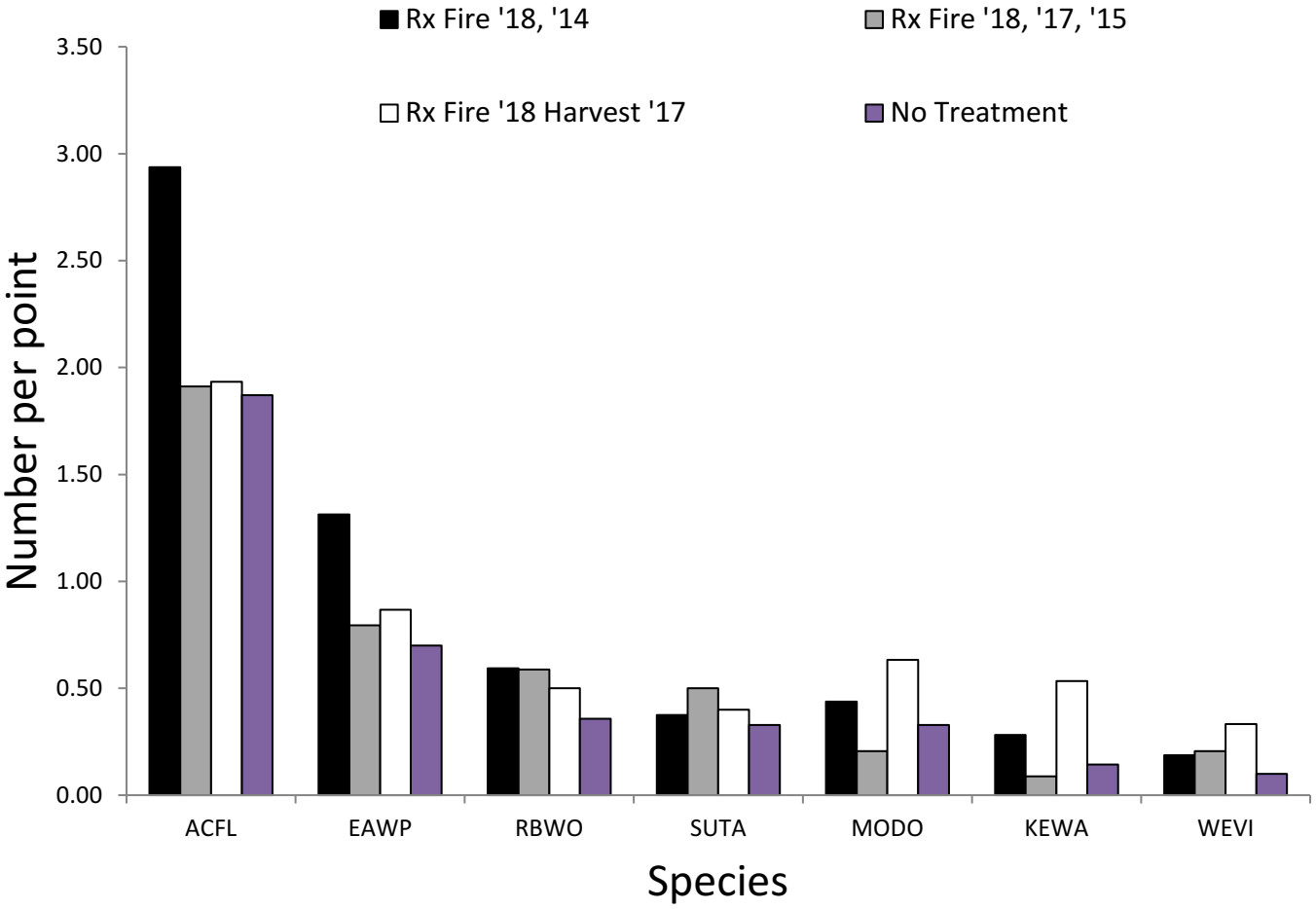

Figure 10. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Trail of Tears** during the 2018 breeding season showing **positive** responses to different types of forest management. Species codes and types of management defined in species table for this site.

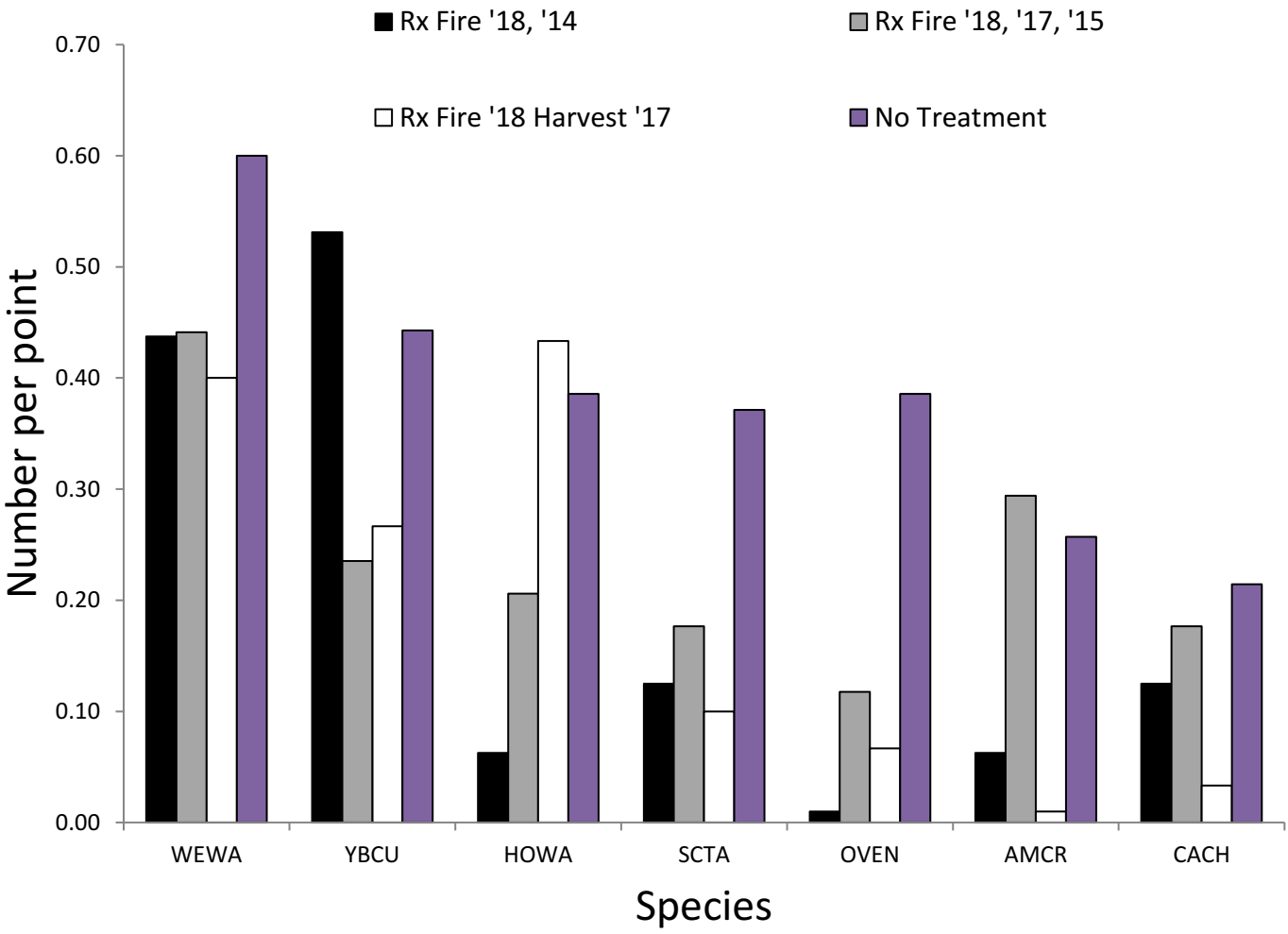

Figure 11. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Trail of Tears** during the 2018 breeding season showing **negative** responses to different types of forest management. Species codes and types of management defined in species table for this site.

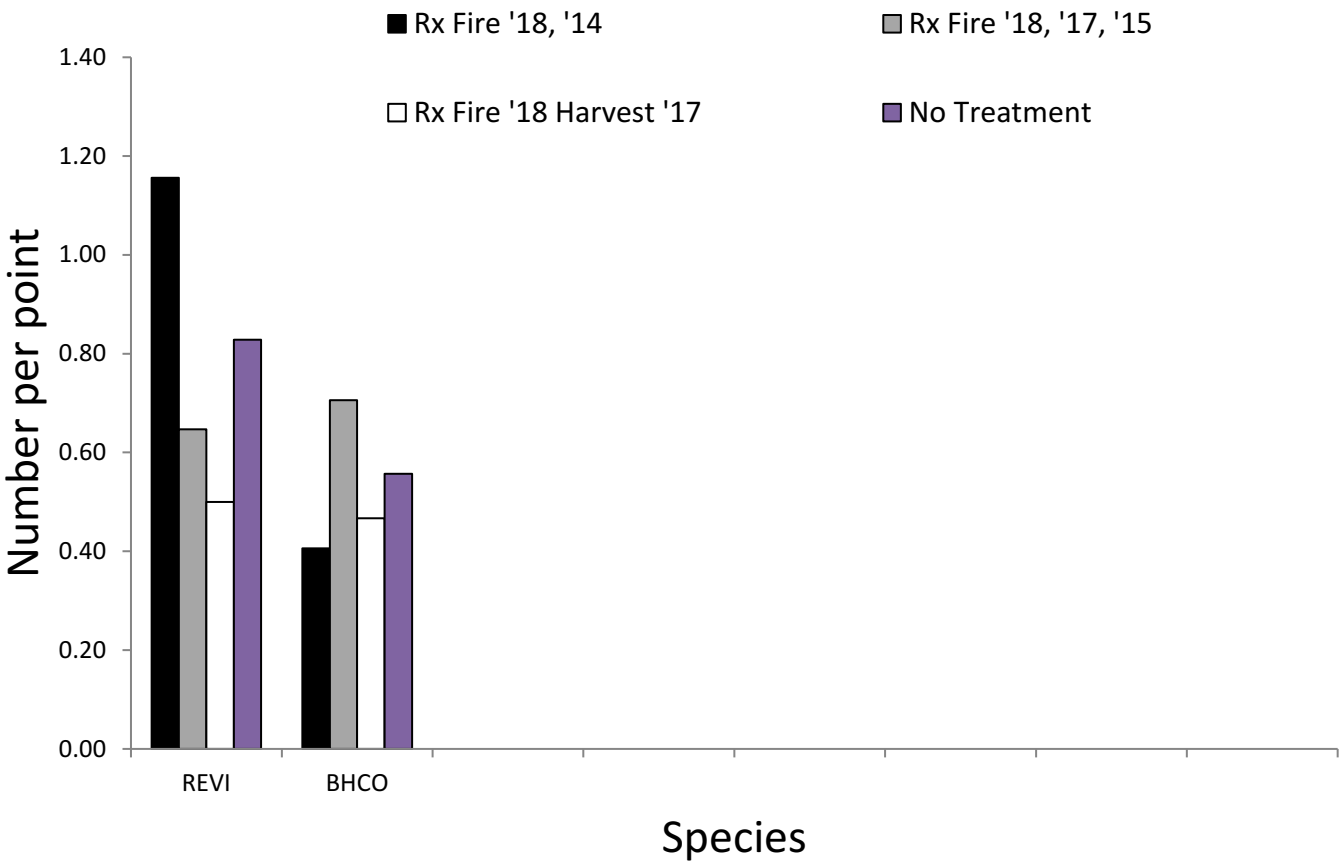

Figure 12. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Trail of Tears** during the 2018 breeding season showing **mixed** responses to different types of forest management. Species codes and types of management defined in species table for this site.

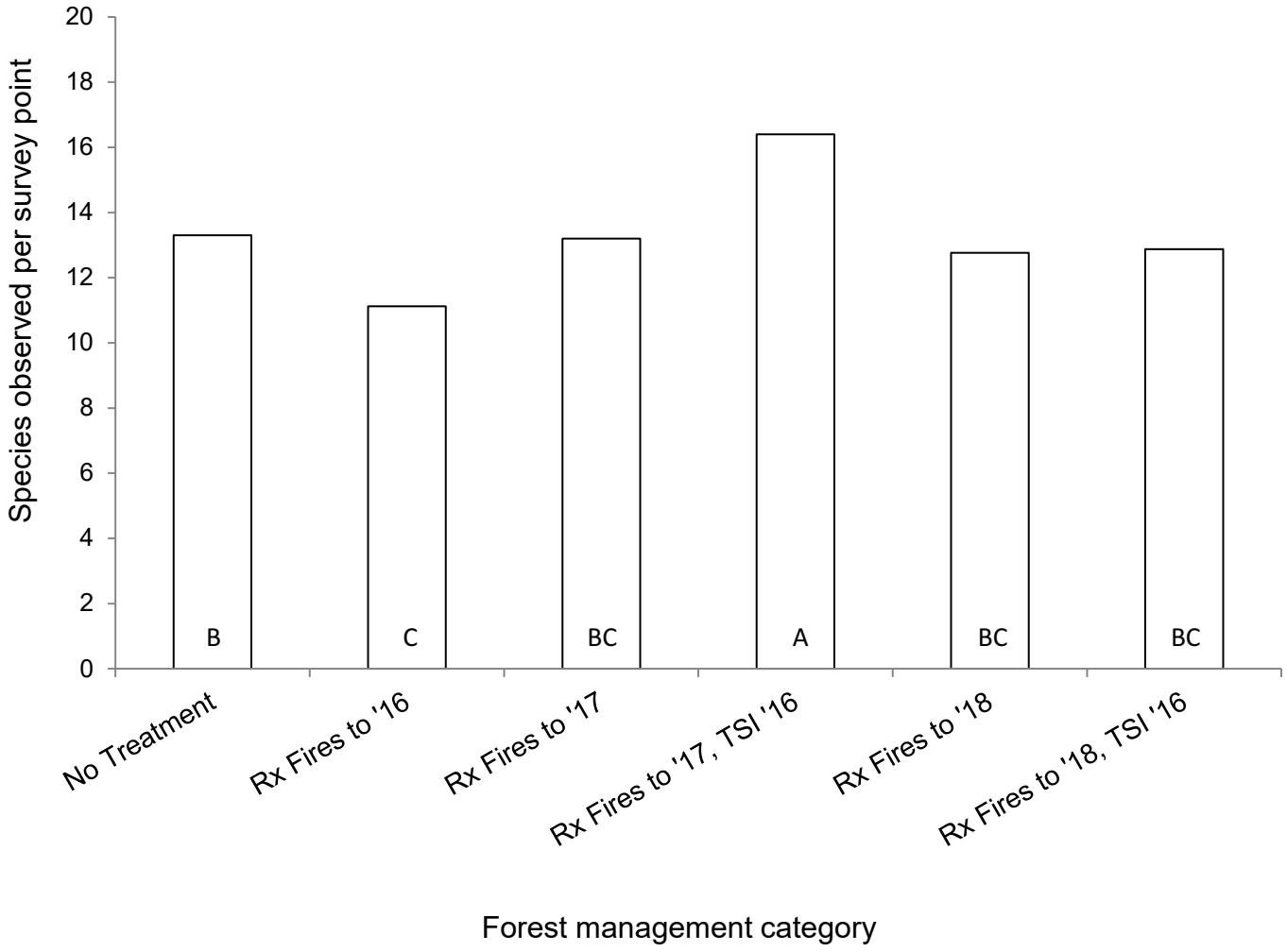

Figure 13. Index of species diversity (mean number of species observed per 100-m-radius survey point) compared among forest treatment categories at **Forbes State Recreation Area** during the 2018 breeding season. See Table 1 for number of survey points per category and description of management. Overall differences were significant (F=2.54, df=5, 65, P=0.037). Categories with the same letter are not different from each other.

Table 5. Results of bird surveys completed during the 2018 breeding season at Stephen A. Forbes State Recreation Area, Illinois. Species ranked from most to least abundant based on total point counts. Values represent number of individuals seen per point (averaged for 2 visits to each point) averaged across points within each category.

		Number per 100-m radius point						
		Management***						
Species Code*	Species**	Rx Fires to '16 (8)	Rx Fires to '17 (10)	Rx Fires to '17, TSI '16 (5)	Rx Fires to '18 (30)	Rx Fires to '18, TSI '16 (8)	NONE (10)	Total (n=78)
TUTI(+)	Tufted Titmouse	0.94	1.35	0.60	1.10	1.94	0.40	1.09
EAWP(+)	Eastern Wood Peewee	0.94	0.90	1.50	0.93	1.13	0.75	0.96
BHCO(-)	Brown-headed Cowbird	0.75	0.45	0.10	0.65	1.06	1.05	0.75
ACFL(- +)	***Acadian Flycatcher***	1.13	0.50	1.40	0.50	0.50	1.05	0.72
NOCA(- +)	Northern Cardinal	0.81	0.50	1.10	0.52	0.50	0.85	0.60
BGGN(+)	Blue-gray Gnatcatcher	0.44	0.40	0.90	0.63	0.50	0.40	0.58
INBU(+ -)	Indigo Bunting	0.13	0.85	0.90	0.52	0.56	0.45	0.53
RBWO(+)	Red-bellied Woodpecker	0.56	0.80	0.40	0.43	0.25	0.25	0.46
CHIC(+)	Chickadee spp.	0.25	0.40	0.70	0.45	0.81	0.35	0.45
WBNU(+)	White-breasted Nuthatch	0.38	0.35	0.90	0.35	0.81	0.35	0.44
YBCU(+)	***Yellow-billed Cuckoo***	0.56	0.35	0.50	0.45	0.25	0.25	0.43
GCFL(+)	Great Crested Flycatcher	0.31	0.55	0.70	0.35	0.56	0.25	0.40
REVI(- +)	Red-eyed Vireo	0.50	0.05	0.70	0.22	0.31	0.45	0.30
RTHU(- +)	Ruby-throated Hummingbir	0.19	0.55	0.60	0.15	0.06	0.35	0.26
BLJA(- +)	Blue Jay	0.00	0.20	0.10	0.27	0.44	0.25	0.25
CARW(- +)	Carolina Wren	0.25	0.35	0.50	0.17	0.06	0.35	0.22
DOWO	Downy Woodpecker	0.25	0.20	0.20	0.23	0.31	0.25	0.22
SUTA(+)	Summer Tanager	0.19	0.15	0.30	0.20	0.19	0.05	0.20
OVEN(+)	***Ovenbird***	0.06	0.00	0.60	0.25	0.19	0.10	0.19
KEWA(- +)	***Kentucky Warbler***	0.00	0.10	0.50	0.15	0.19	0.30	0.17
AMCR(- +)	American Crow	0.00	0.25	0.00	0.17	0.31	0.20	0.17
YTVI(+)	Yellow-throated Vireo	0.13	0.20	0.30	0.13	0.13	0.10	0.14
LOWA(+ -)	Louisiana Waterthrush	0.13	0.10	0.20	0.15	0.00	0.10	0.13
MODO(+ -)	Mourning Dove	0.13	0.05	0.00	0.23	0.06	0.10	0.13
NOPA	Northern Parula	0.06	0.05	0.10	0.08	0.06	0.20	0.08
AMGO	American Goldfinch	0.06	0.05	0.20	0.08	0.00	0.10	0.08
COYE	Common Yellowthroat	0.00	0.15	0.00	0.10	0.00	0.15	0.08
PROW	Prothonotary Warbler	0.13	0.10	0.00	0.10	0.00	0.05	0.08
RWBL	Red-winged Blackbird	0.31	0.10	0.10	0.07	0.00	0.00	0.08
RHWO	***Red-headed Woodpecker***	0.00	0.05	0.00	0.08	0.06	0.00	0.06
WAVI	Warbling Vireo	0.06	0.20	0.10	0.03	0.00	0.00	0.05
WOTH	***Wood Thrush***	0.00	0.00	0.00	0.05	0.06	0.10	0.05
EABL	Eastern Bluebird	0.00	0.00	0.00	0.02	0.06	0.05	0.04
FISP	***Field Sparrow***	0.00	0.05	0.00	0.07	0.00	0.00	0.04
HAWO	Hairy Woodpecker	0.00	0.00	0.10	0.02	0.06	0.05	0.04
SCTA	Scarlet Tanager	0.00	0.05	0.00	0.05	0.06	0.00	0.04
YBCH	***Yellow-breasted Chat***	0.00	0.05	0.00	0.00	0.00	0.10	0.04
BAOR	Baltimore Oriole	0.00	0.10	0.00	0.02	0.00	0.05	0.03
CAGO	Canada Goose	0.00	0.00	0.00	0.00	0.31	0.00	0.03
CHSP	Chipping Sparrow	0.06	0.00	0.00	0.07	0.00	0.00	0.03
PIWO	Pileated Woodpecker	0.00	0.05	0.00	0.05	0.00	0.00	0.03
AMRO	American Robin	0.00	0.10	0.00	0.00	0.00	0.10	0.03
BBCU	***Black-billed Cuckoo***	0.00	0.00	0.00	0.02	0.00	0.15	0.03
EATO	Eastern Towhee	0.00	0.10	0.00	0.02	0.00	0.00	0.03
YTWA	Yellow-throated Warbler	0.00	0.05	0.00	0.03	0.00	0.05	0.03
EAPH	Eastern Phoebe	0.00	0.00	0.00	0.02	0.00	0.00	0.02
TRSW	Tree Swallow	0.00	0.00	0.10	0.03	0.00	0.00	0.02
CEDW	Cedar Waxwing	0.00	0.00	0.00	0.03	0.00	0.00	0.01
COGR	Common Grackle	0.00	0.00	0.20	0.00	0.00	0.00	0.01
NOBO	***Northern Bobwhite***	0.00	0.10	0.00	0.00	0.00	0.00	0.01
RBGR	Rose-breasted Grosbeak	0.00	0.00	0.00	0.03	0.00	0.00	0.01
RSHA	***Red-shouldered Hawk***	0.06	0.00	0.00	0.00	0.00	0.00	0.01
RTHA	Red-tailed Hawk	0.00	0.00	0.00	0.02	0.06	0.00	0.01
WEVI	White-eyed Vireo	0.00	0.00	0.00	0.00	0.00	0.05	0.01
BADO	Barred Owl	0.00	0.00	0.00	0.02	0.00	0.00	0.01
BLGR	***Blue Grosbeak***	0.00	0.00	0.00	0.02	0.00	0.00	0.01
BRCR	***Brown Creeper***	0.00	0.00	0.10	0.00	0.00	0.00	0.01
HOWR	House Wren	0.00	0.00	0.00	0.02	0.00	0.00	0.01
TUVU	Turkey Vulture	0.00	0.05	0.00	0.00	0.00	0.00	0.01
WODU	***Wood Duck***	0.00	0.05	0.00	0.00	0.00	0.00	0.01

* (+) = positive, (-) = negative, and (+ -) = mixed response of relative abundance to management.

** Species on the Species in Greatest Need of Conservation (SGNC) list are given in bold and italics.

*** Rx Fire = prescribed fire; TSI = Timber Stand Improvement (e.g. thinning). Parenthetical () is number of points.

= species that were more abundant (>0.20) overall and responded to forest management.

= species that were less abundant (0.10-0.20) overall and responded to forest management.

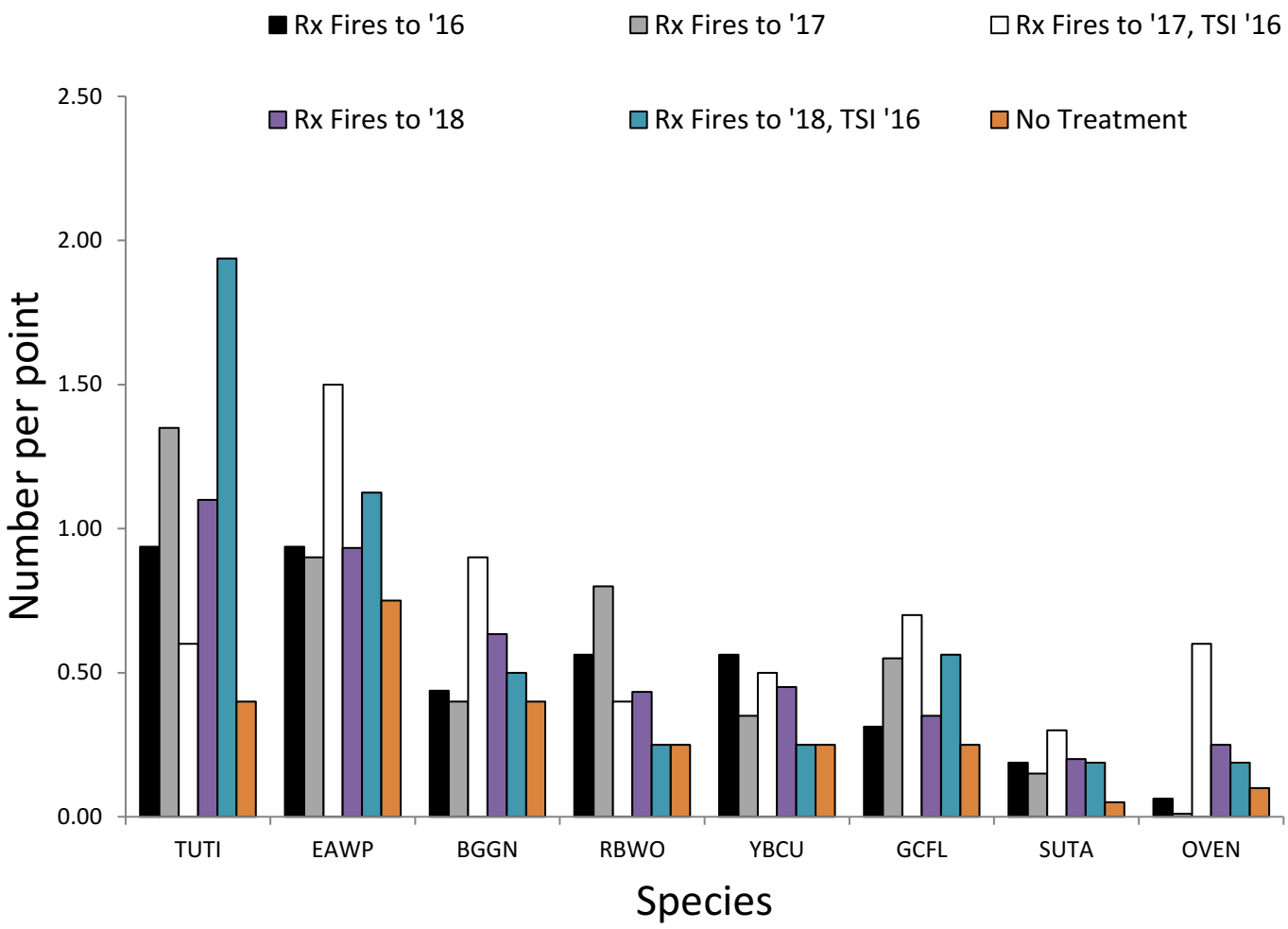

Figure 14. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Forbes State Recreation Area** during the 2018 breeding season showing **positive** responses to different types of forest management. Species codes and types of management defined in species table for this site.

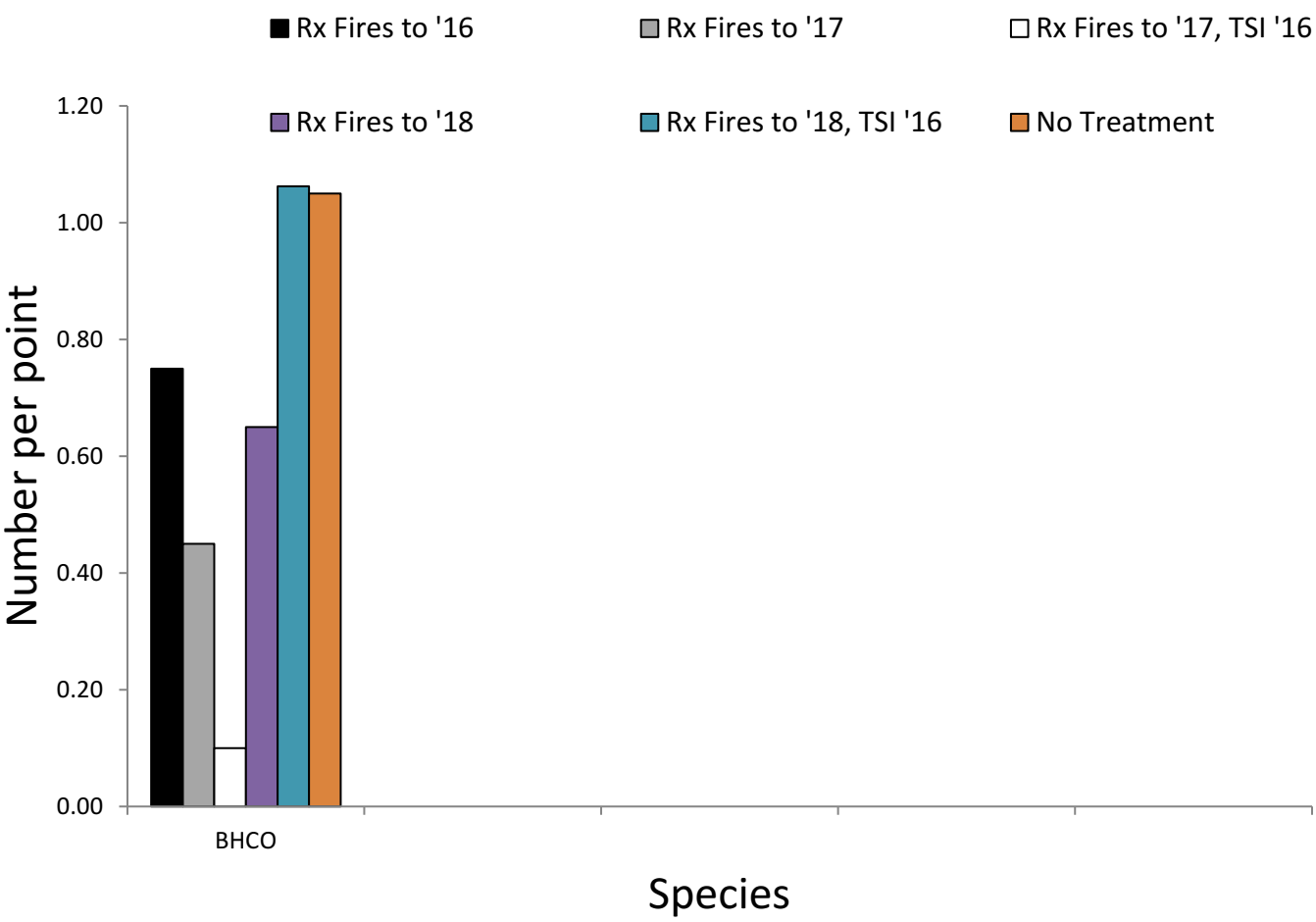

Figure 15. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Forbes State Recreation Area** during the 2018 breeding season showing **negative** responses to different types of forest management. Species codes and types of management defined in species table for this site.

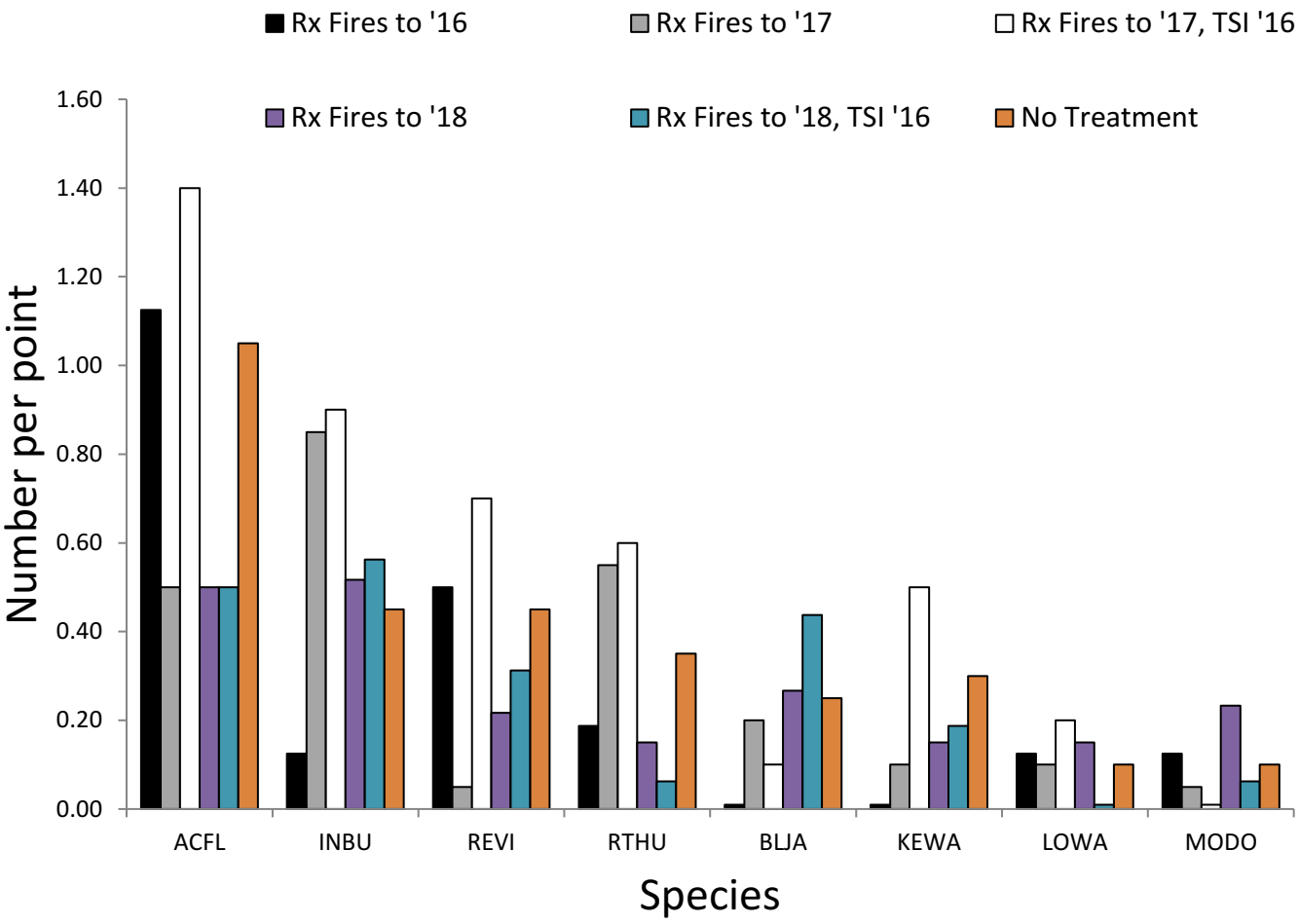

Figure 16. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Forbes State Recreation Area** during the 2018 breeding season showing **mixed** responses to different types of forest management. Species codes and types of management defined in species table for this site.

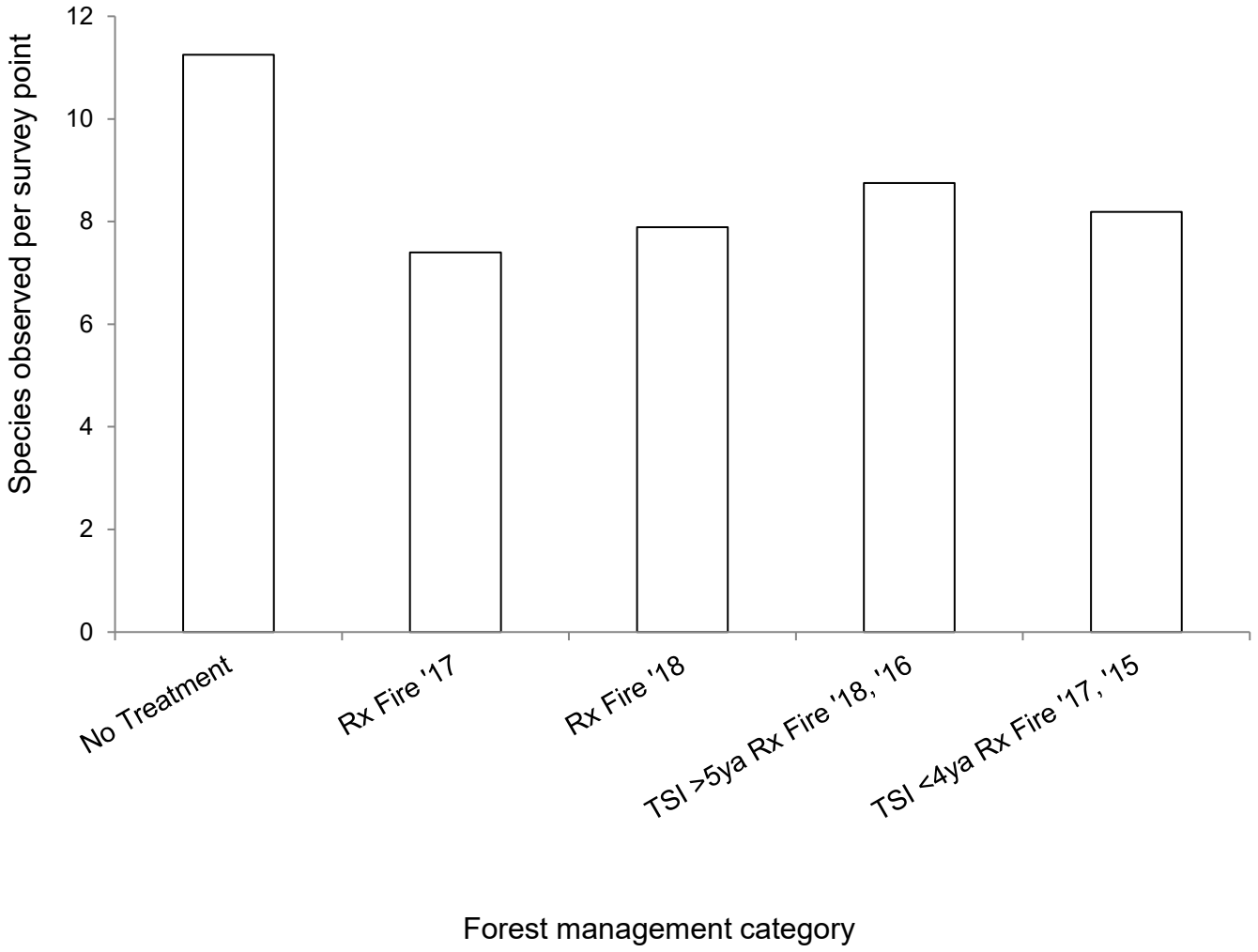

Figure 17. Index of species diversity (mean number of species observed per 100-m-radius survey point) compared among forest treatment categories at **Siloam Springs State Park** during the 2018 breeding season. See Table 1 for number of survey points per category and description of management. Overall differences were significant (F=1.93, df=4, 37, P=0.13).

Table 6. Results of bird surveys completed during the 2018 breeding season at Siloam Springs State Park, Illinois. Species ranked from most to least abundant based on total point counts. Values represent number of individuals seen per point averaged across points within each category.

		Number per 100-m radius point					
		Management***					
Species Code*	Species**	Rx Fire '17 (5)	Rx Fire '18 (9)	TSI >5ya Rx Fire '18, '16 (8)	TSI <4ya Rx Fire '17, '15 (16)	None (4)	Total (n=42)
INBU(+)	Indigo Bunting	0.40	0.67	1.00	1.56	0.00	0.98
BHCO(-)	Brown-headed Cowbird	0.20	0.67	0.63	1.19	1.75	0.90
EAWP(- +)	***Eastern Wood Peewee***	0.60	0.78	1.38	0.63	1.00	0.83
WBNU(-)	White-breasted Nuthatch	0.60	1.00	0.50	0.31	1.75	0.67
ACFL(-)	***Acadian Flycatcher***	0.60	0.67	0.88	0.44	1.00	0.64
AMRO(- +)	American Robin	0.40	1.44	0.13	0.31	0.50	0.55
REVI(-)	Red-eyed Vireo	0.80	0.56	0.50	0.19	0.75	0.45
NOCA(+)	Northern Cardinal	0.80	0.44	0.50	0.38	0.00	0.43
TUTI	Tufted Titmouse	0.40	0.56	0.38	0.31	0.50	0.40
BLJA(-)	Blue Jay	0.60	0.22	0.13	0.50	0.50	0.38
BGGN(-)	Blue-gray Gnatcatcher	0.00	0.56	0.50	0.25	0.50	0.36
CARW(+ -)	Carolina Wren	0.20	0.56	0.13	0.25	0.25	0.29
RBGR(+)	Rose-breasted Grosbeak	0.20	0.44	0.25	0.19	0.25	0.26
SCTA(-)	Scarlet Tanager	0.20	0.22	0.13	0.31	0.50	0.26
SUTA(-)	Summer Tanager	0.00	0.11	0.25	0.38	0.50	0.26
EATO(+)	Eastern Towhee	0.20	0.22	0.00	0.44	0.00	0.24
DOWO(+ -)	Downy Woodpecker	0.20	0.00	0.38	0.25	0.25	0.21
OVEN(-)	***Ovenbird***	0.20	0.22	0.00	0.31	0.25	0.21
WOTH(-)	***Wood Thrush***	0.00	0.22	0.13	0.13	1.00	0.21
KEWA(+)	***Kentucky Warbler***	0.40	0.11	0.00	0.31	0.00	0.19
RHWO(+ -)	***Red-headed Woodpecker***	0.40	0.00	0.00	0.31	0.25	0.19
CHSP(-)	Chickadee spp.	0.00	0.11	0.13	0.13	0.75	0.17
RBWO(-)	Red-bellied Woodpecker	0.00	0.00	0.38	0.06	0.50	0.14
RTHU(- +)	Ruby-throated Hummingbird	0.00	0.11	0.38	0.06	0.25	0.14
NOPA(+)	Northern Parula	0.00	0.00	0.13	0.25	0.00	0.12
GCFL(- +)	Great Crested Flycatcher	0.40	0.00	0.00	0.06	0.25	0.10
YBCH(+)	***Yellow-breasted Chat***	0.00	0.00	0.38	0.06	0.00	0.10
AMGO	American Goldfinch	0.00	0.00	0.00	0.19	0.00	0.07
COYE	Common Yellowthroat	0.00	0.00	0.25	0.06	0.00	0.07
EABL	Eastern Bluebird	0.00	0.11	0.25	0.00	0.00	0.07
BADO	Barred Owl	0.00	0.00	0.13	0.06	0.00	0.05
FISP	Field Sparrow	0.00	0.00	0.25	0.00	0.00	0.05
MODO	Mourning Dove	0.20	0.00	0.13	0.00	0.00	0.05
YTVI	Yellow-throated Vireo	0.20	0.00	0.13	0.00	0.00	0.05
GHOW	Great Horned Owl	0.00	0.00	0.00	0.06	0.00	0.02
GRCA	Gray Catbird	0.20	0.00	0.00	0.00	0.00	0.02
HAWO	Hairy Woodpecker	0.00	0.00	0.00	0.06	0.00	0.02
NOFL	***Northern Flicker***	0.00	0.00	0.00	0.06	0.00	0.02
PIWO	Pileated Woodpecker	0.00	0.11	0.00	0.00	0.00	0.02
SOSP	Song Sparrow	0.00	0.00	0.13	0.00	0.00	0.02
TUVU	Turkey Vulture	0.00	0.00	0.00	0.06	0.00	0.02
WEVI	White-eyed Vireo	0.00	0.00	0.00	0.00	0.25	0.02
YEWA	Yellow Warbler	0.00	0.00	0.13	0.00	0.00	0.02

* (+) = positive, (-) = negative, and (+ -) = mixed response of relative abundance to management.

** Species on the Species in Greatest Need of Conservation (SGNC) list are given in bold and italics.

*** Rx Fire = prescribed fire; TSI = Timber Stand Improvement (e.g. thinning). Parenthetical () is number of points.

= species that were more abundant (>0.20) overall and responded to forest management.

= species that were less abundant (0.10-0.20) overall and responded to forest management.

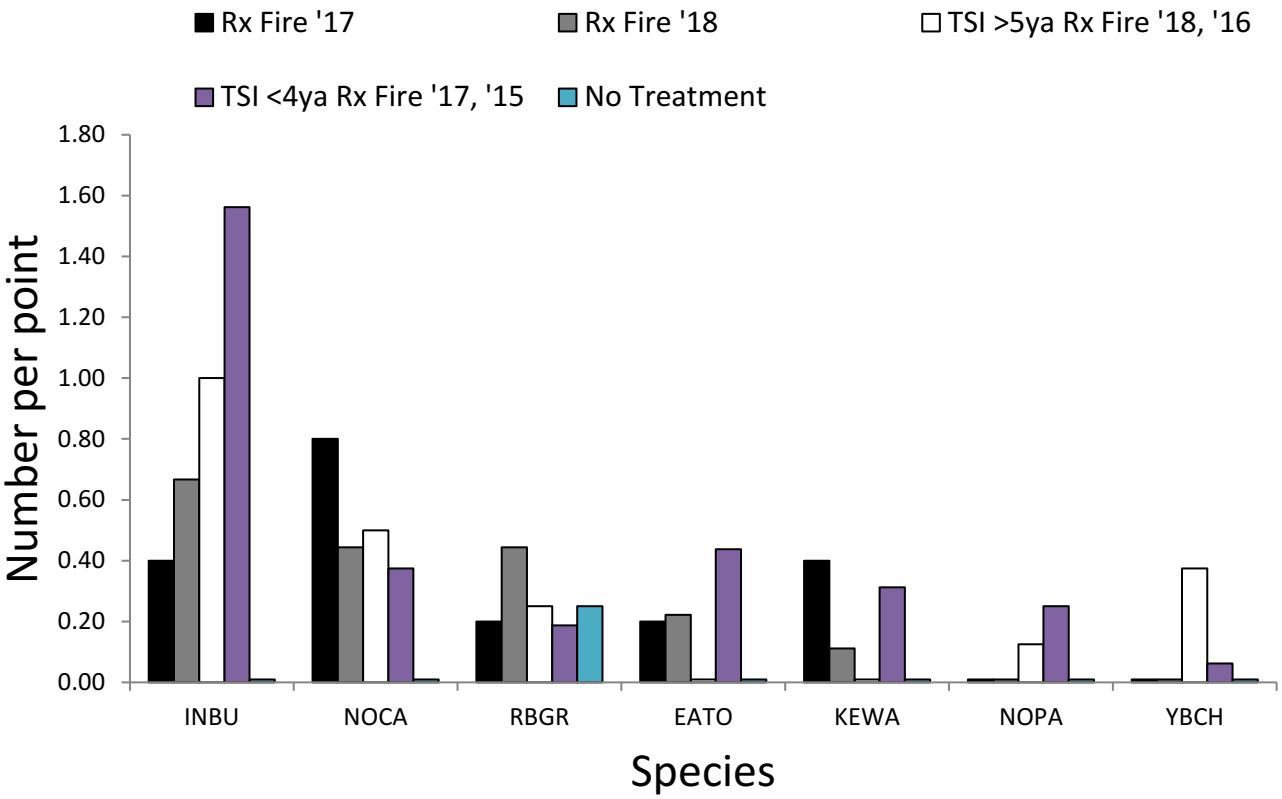

Figure 18. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Siloam Springs State Park** during the 2018 breeding season showing **positive** responses to different types of forest management. Species codes and types of management defined in species table for this site.

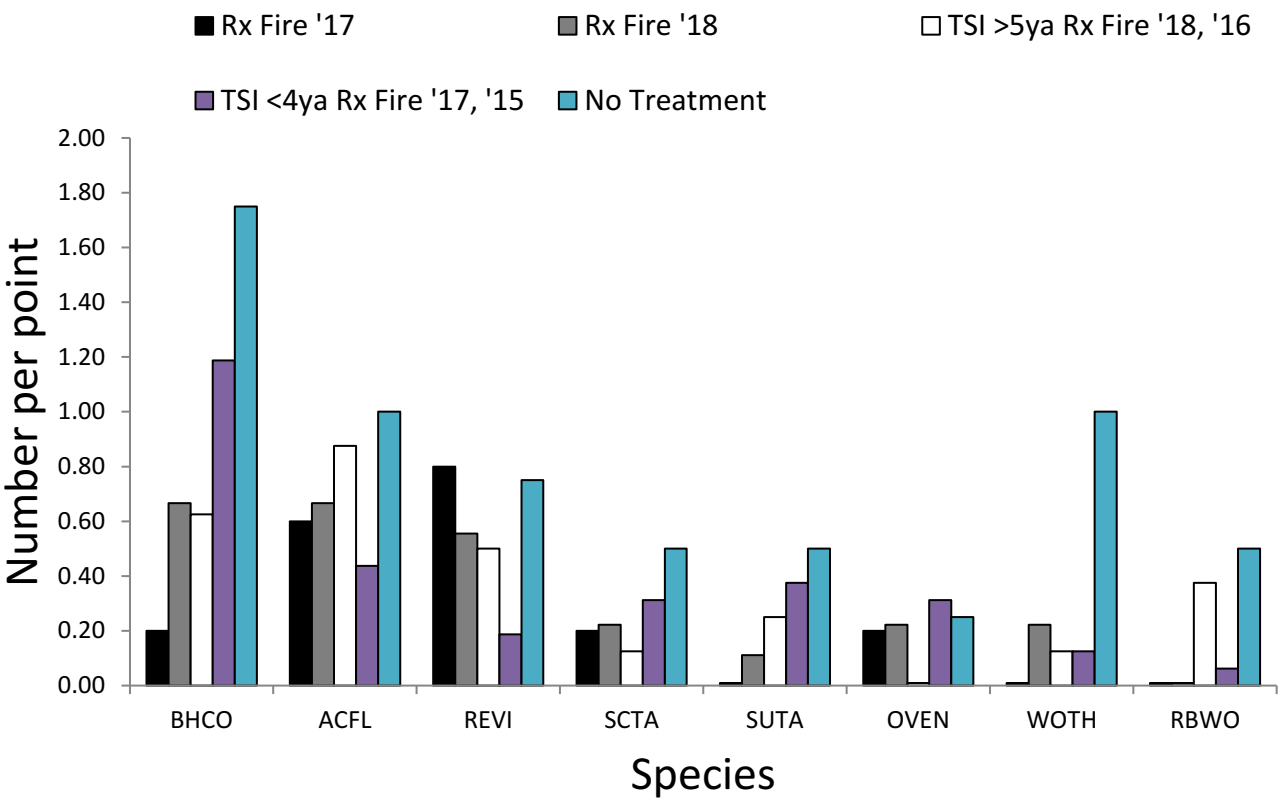

Figure 19. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Siloam Springs State Park** during the 2018 breeding season showing **negative** responses to different types of forest management. Species codes and types of management defined in species table for this site.

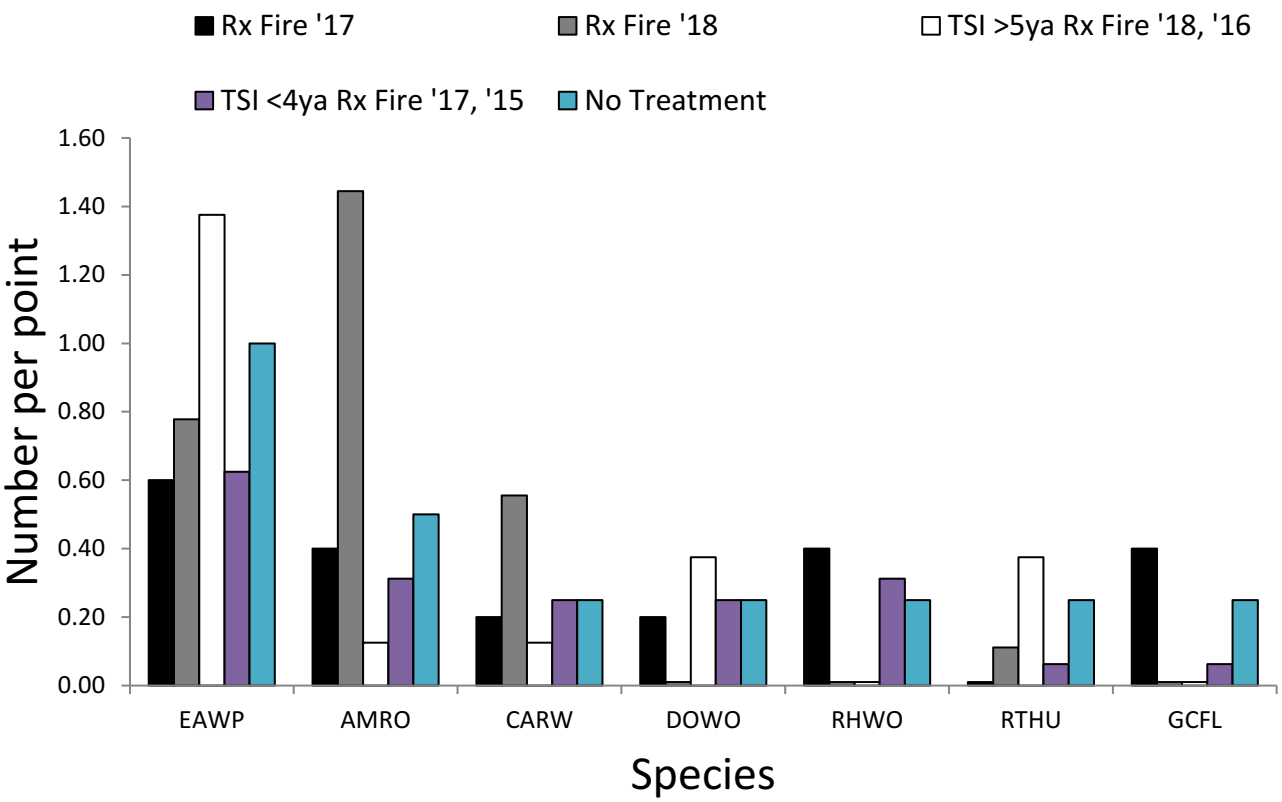

Figure 20. Relative abundance (average number of individuals observed per 100-m-radius survey point) of various bird species at **Siloam Springs State Park** during the 2018 breeding season showing **mixed** responses to different types of forest management. Species codes and types of management defined in species table for this site.

Table 7. Structural aspects of the forest vegetation at Forest Campaign sites (Oakwood Bottoms) in 2018. Averages per point presented. Fewer than expected veg surveys completed due to flooding.

	Management Type* (number of veg survey points)			
Vegetation Characteristic	None (5)	TSI >4ya, Rx Fire >4ya (14)	TSI <4ya, Rx Fire >4ya (2)	TSI<4ya MR18 (3)
Size A Trees (3-10" dbh)	31.2	30.9	3.0	4.0
Size B Trees (11-24" dbh)	8.4	4.6	1.0	4.0
Size C Trees (25-38" dbh)	1.8	2.3	2.0	1.0
Size D Trees (>38" dbh)	0.2	0.5	0.0	0.0
Total Trees	41.6	38.2	6.0	9.0
Size A Snags (3-10" dbh)	3.0	1.8	3.0	0.7
Size B Snags (11-24" dbh)	0.8	0.9	0.0	0.3
Size C Snags (25-38" dbh)	0.0	0.4	0.0	0.0
Size D Snags (>38" dbh)	0.0	0.1	0.0	0.0
Total Snags	3.8	3.2	3.0	1.0
Shrub Density**	25.2	43.3	8.5	24.0
Shrub Height (m)	2.4	1.9	0.8	1.5
Ground Cover (%)	76.0	81.8	100.0	63.3
Canopy Cover (%)	90.0	67.5	15.0	43.3
Canopy Height (m)	19.2	19.9	6.5	15.3

* TSI = Timber Stand Improvement (thinning); Rx Fire = Prescribed Fire; MR = Mid-story Removal.

** number of woody stems < 2-inch dbh detected along 2 perpendicular transects through center of 11-meter-radius veg survey location.

Table 8. Structural aspects of the forest vegetation at Forest Campaign sites (Lake Shelbyville) in 2018. Averages per point presented.

	Management Type* (number of veg survey points)						
Vegetation Characteristic	None (21)	Rx Fire >5ya (9)	TSI >5ya (15)	Rx Fire >5ya, TSI >5ya (9)	Rx Fire <5ya, TSI >5ya (16)	SPRAY '18, Rx Fire '17, TSI >5ya (7)	SPRAY '18, Rx Fire '18 (8)
Size A Trees (3-10" dbh)	12.7	13.6	16.4	5.2	10.0	8.7	9.1
Size B Trees (11-24" dbh)	5.8	5.8	6.4	4.1	5.6	7.7	6.0
Size C Trees (25-38" dbh)	0.3	0.8	1.5	1.1	1.1	0.0	0.9
Size D Trees (>38" dbh)	0.1	0.3	0.1	0.1	0.0	0.0	0.0
Total Trees	18.9	20.4	24.3	10.6	16.7	16.4	16.0
Size A Snags (3-10" dbh)	2.2	1.6	1.8	0.0	1.7	2.4	2.6
Size B Snags (11-24" dbh)	0.4	0.2	1.1	0.2	0.4	0.6	0.3
Size C Snags (25-38" dbh)	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Size D Snags (>38" dbh)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Snags	2.6	1.8	2.9	0.2	2.1	3.0	2.9
Shrub Density**	19.3	27.1	29.7	8.9	16.8	19.1	38.1
Shrub Height (m)	1.9	1.5	2.2	1.5	1.6	1.6	1.4
Ground Cover (%)	45.5	63.9	54.0	57.2	61.9	30.7	54.4
Canopy Cover (%)	77.1	76.7	77.3	66.7	65.0	73.6	69.4
Canopy Height (m)	15.4	16.6	17.3	16.1	16.4	16.7	14.9

* TSI = Timber Stand Improvement (thinning); Rx Fire = Prescribed Fire; SPRAY = aerial application of herbicide for invasive shrubs (e.g. bush honeysuckle).

** number of woody stems < 2-inch dbh detected along 2 perpendicular transects through center of 11-meter-radius veg survey location.

Table 9. Structural aspects of the forest vegetation at Forest Campaign sites (Trail of Tears) in 2018. Averages per point presented.

	Management Type* (number of veg survey points)			
Vegetation Characteristic	None (17)	Rx Fire '18 '14 (8)	Rx Fire '18 '17 '15 (9)	Rx Fire '18, Harverst '17 (8)
Size A Trees (3-10" dbh)	8.1	14.8	12.6	7.9
Size B Trees (11-24" dbh)	1.5	2.0	3.2	2.9
Size C Trees (25-38" dbh)	1.2	1.8	1.4	0.8
Size D Trees (>38" dbh)	0.1	0.5	0.6	0.4
Total Trees	10.9	19.0	17.8	11.9
Size A Snags (3-10" dbh)	0.6	1.9	0.8	0.8
Size B Snags (11-24" dbh)	0.0	0.1	0.3	0.0
Size C Snags (25-38" dbh)	0.0	0.0	0.0	0.0
Size D Snags (>38" dbh)	0.0	0.0	0.0	0.0
Total Snags	0.6	2.0	1.1	0.8
Shrub Density**	18.5	31.8	21.7	13.0
Shrub Height (m)	1.8	1.6	2.1	1.3
Ground Cover (%)	48.5	44.4	49.4	65.0
Canopy Cover (%)	84.7	84.4	68.3	48.8
Canopy Height (m)	15.3	22.0	20.6	17.6

* Harvest = Single-tree Selection; Rx Fire = Prescribed Fire.

** number of woody stems < 2-inch dbh detected along 2 perpendicular transects through center of 11-meter-radius veg survey location.

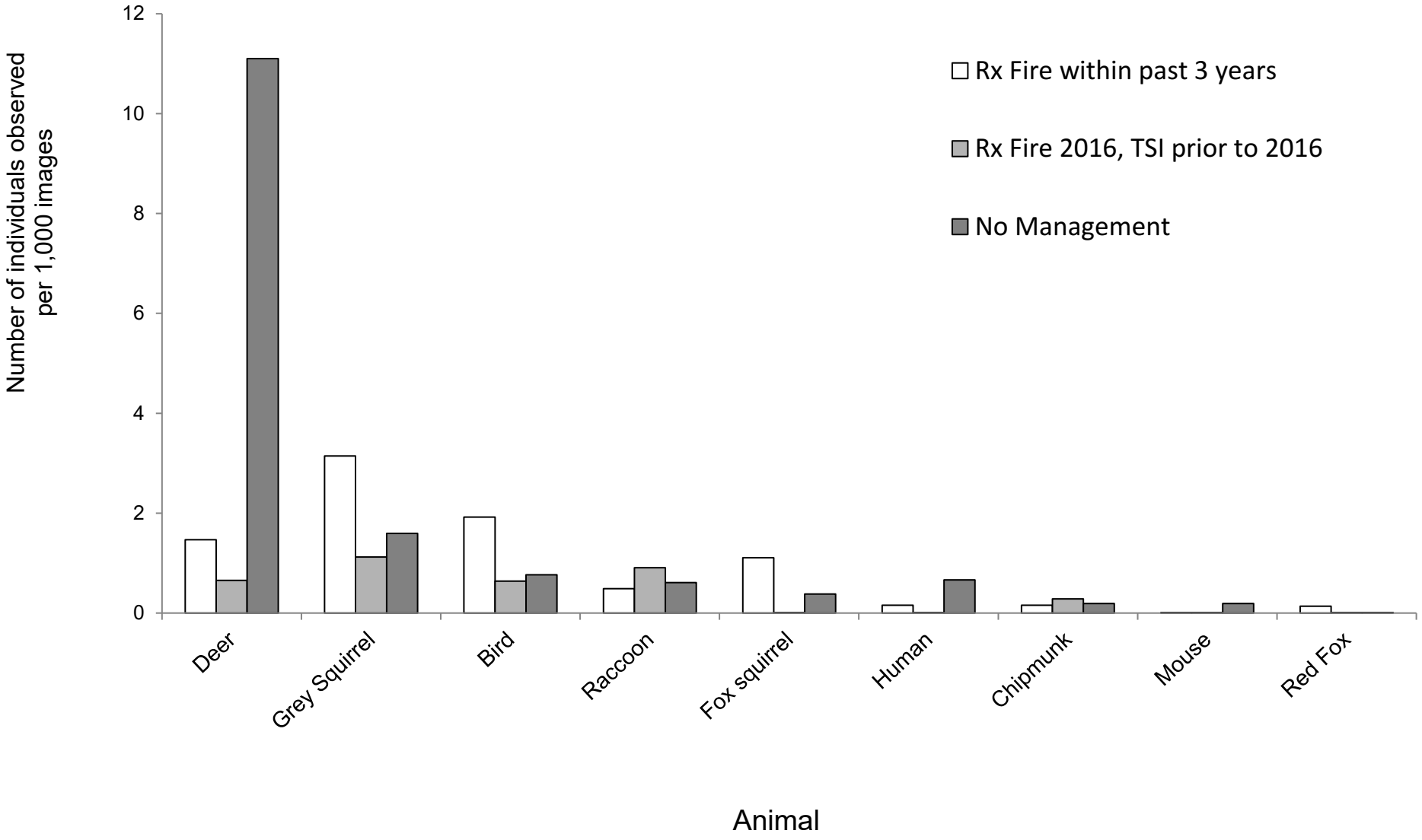

Figure 21. Capture rates for various animals that were photographed at **baited** camera traps during early summer 2018 at survey points associated with different forest management categories at **Lake Shelbyville**. Total number of images screened was 34,192 in the three categories combined. Animals listed from most to least "captured".

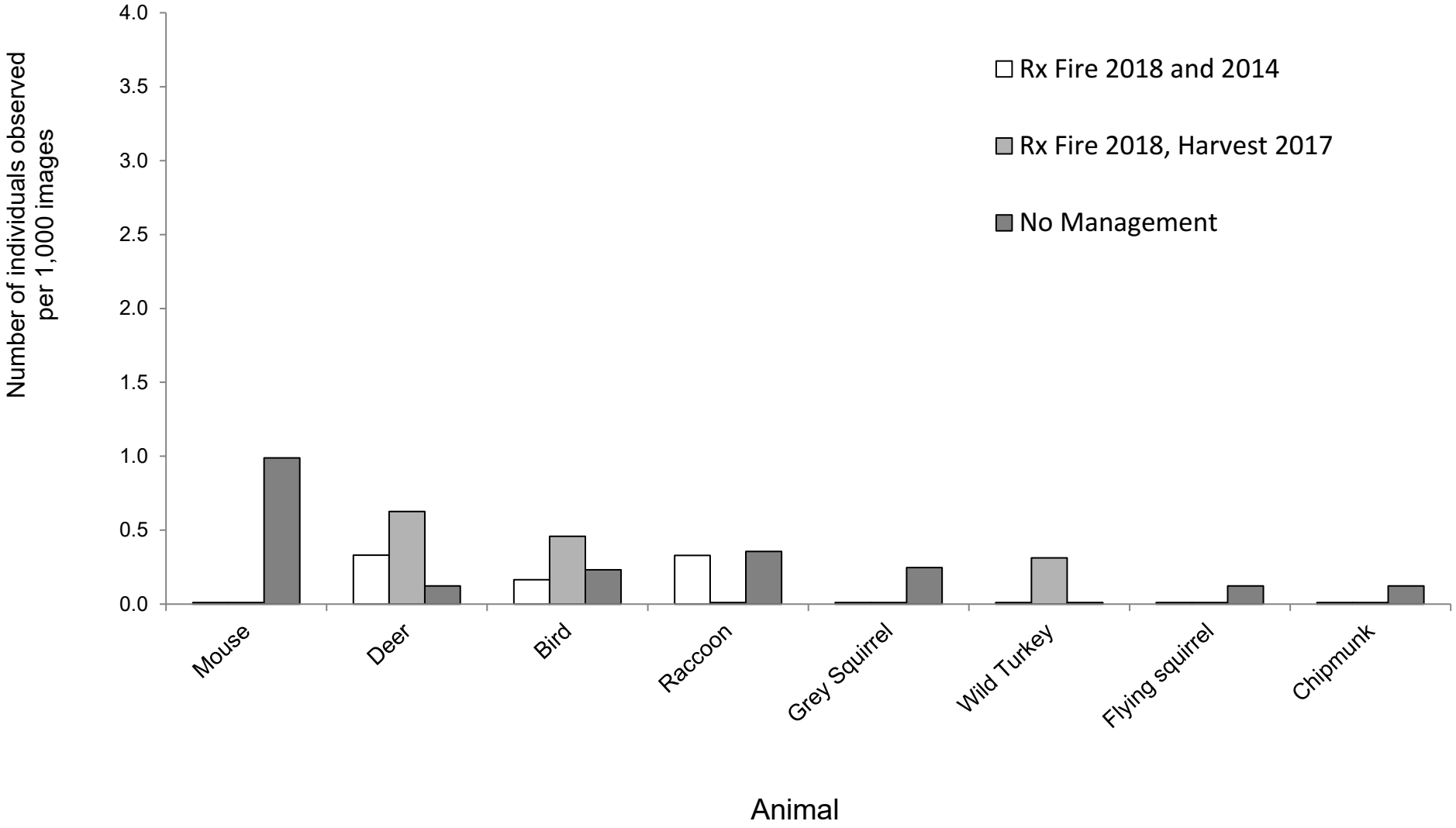

Figure 22. Capture rates for various animals that were photographed at **baited** camera traps during early summer 2018 at survey points associated with different forest management categories at **Trail of Tears State Forest**. Total number of images screened was 20,804 in the three categories combined. Animals listed from most to least "captured".

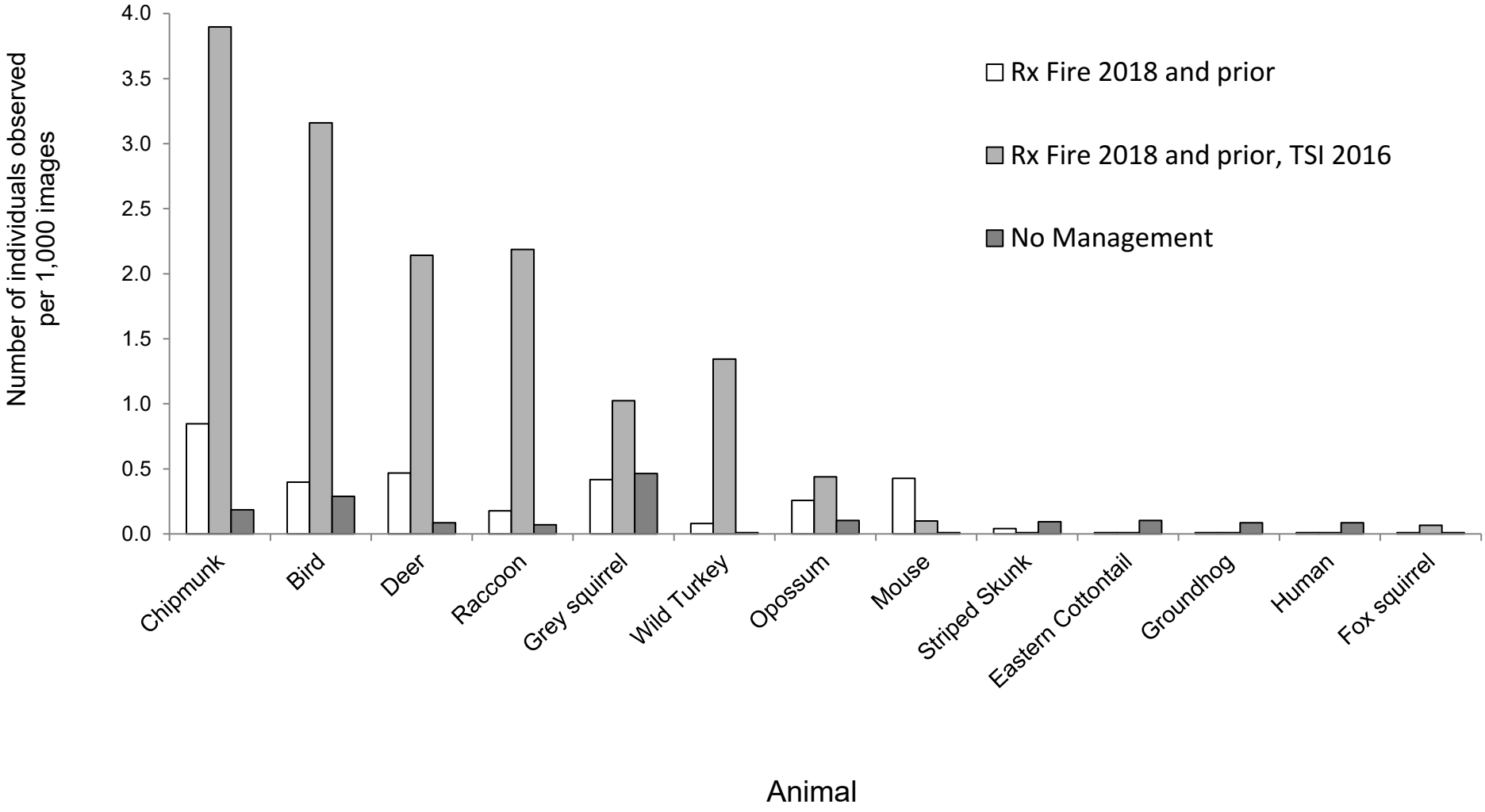

Figure 23. Capture rates for various animals that were photographed at **baited** camera traps during early summer 2018 at survey points associated with different forest management categories at **Stephen A. Forbes State Park**. Total number of images screened was 46,112 in the three categories combined. Animals listed from most to least "captured".